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Short selling and trade credit: New evidence

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ABSTRACT

This study investigates the effect of short sales on firms' use of trade credit. Using a sample of 3262 Chinese listed firms from 2007 to 2019, the analysis results show that both the deregulation and the magnitude of short sales negatively affect trade credit. The transmission mechanism indicates that firms' access to formal financing decreases after short sales deregulation, which mitigates firms' ability to redistribute formal financing through trade credit. Moreover, the results suggest that shortable firms tend to adopt a moderate trade credit policy and adjust their trade credit to the target level at a lower rate than non-shortable firms. This study reveals the features of the short sales–trade credit relationship in an emerging market.

1. Introduction

Trade credit is one of the main channels through which firms access short-term financing (Abdulla et al., 2017; Bastos & Pindado, 2013). This is especially the case for firms in the Chinese market, which has considerable financial constraints and informal financing channels (e.g., trade credit) (Lin & Chou, 2015; Wang et al., 2019). According to Tang and Moro (2020), the average use of trade payables by non-financial listed firms in China accounted for 48.53% of these firms' average current liabilities in 2008, but this ratio increased to 49.21% in 2017. In contrast, the average ratio of short-term bank loans to the current liabilities of these firms decreased from 31.32% in 2008 to 23.60% in 2017 (Tang & Moro, 2020). Trade credit may compensate for bank loans.

Existing studies have identified a range of firm-specific and macroeconomic factors that influence trade credit, including firm size (Lawrenz & Oberndorfer, 2018), collateral liquidation (Fabbri & Menichini, 2010), state-owned enterprises (SOEs) (Wang et al., 2019), listing status (Abdulla et al., 2020), group affiliation (Hyun, 2021), policy uncertainty (D'Mello & Toscano, 2020), and financial crises (Love et al., 2007). However, little attention has been paid to the links between trade credit and stock market factors, such as short sales. According to modern financial theory, the stock market is not a sideshow but a factor that influences corporate decisions (Grullon et al., 2015). We know that short sales deregulation negatively affects firms' innovation activities (He & Tian, 2015), leads to lower financial leverage (Gong, 2020), and prevents firms from engaging in inefficient mergers and acquisitions (M&As) (Shi et al., 2021). However, it is unclear whether short sales have an impact on the primary short-term financing channel, namely trade credit.

On March 31, 2010, the China Securities Regulatory Commission (CSRC) announced a short sales deregulation program that allowed 90 stocks to be shortable. The number of stocks on the shortable list increased to 278 on December 5, 2011 and reached 1,600[1] on August 9, 2019 (Feng & Chan, 2016). The market capitalization of shortable shares (balance) increased from 11 million yuan in 2010 to nearly 14 billion yuan in 2019.[2] Short sales enable stock prices to quickly incorporate negative information (e.g., Jin et al., 2018). In turn, negative information increases investors' pessimism and leads them to demand higher rewards to compensate for potential losses, increasing firms' financing costs and financial constraints (Meng et al., 2020). With respect to trade credit, financially constrained firms typically do not have sufficient liquidity to redistribute to customers through trade receivables; instead, they use trade payables as a substitute for their scarce formal financing (Lawrenz & Oberndorfer, 2018). However, an opposing

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[2] The data come from the Shanghai and Shenzhen stock exchanges.

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argument posits that short selling poses a threat to managers and pushes managers to disclose (negative) information in a timely manner, which improves the information environment and reduces the information premium demanded by investors (thus decreasing firms' financing costs) (Chen et al., 2018; Hu et al., 2020). Firms that receive low-cost formal financing tend to redistribute such financing to customers through trade receivables but reduce their use of costly trade payables (Abdulla et al., 2020).

In this study, we investigate the effect of short sales on trade credit using a sample of 3262 Chinese firms listed on the A-share market from 2007 to 2019. Although the effects of short sales in developed markets have been discussed extensively in the literature (e.g., Gong, 2020), it is still unclear whether the role played by short sales differs in emerging markets, where information asymmetry is severe. This is the first reason we opt to focus on the Chinese A-share market. According to Chen et al. (2018), short sales can compensate for weak information mechanisms and enhance the information environment. As previously mentioned, the information environment affects firms' financing abilities and trade credit (the financing effect). Consequently, short sales may play a significant role in addressing the severe information asymmetry problem and influencing firms' trade credit in emerging markets. The Chinese A-share market is one of the few fast-growing emerging markets that allows a group of stocks to be sold short, enabling us to compare shortable (firms whose stocks can be sold short) and non-shortable firms and to assess changes in trade credit in the pre- and post-deregulation periods. Second, banks offer preferential borrowing terms to a small group of firms (e.g., SOEs) and discriminate against other firms in China (Wu et al., 2014). In this scenario, financially flexible firms can act as a second layer between banks and financially constrained firms and redistribute liquidity to constrained firms through trade receivables (Wang et al., 2019). Conversely, financially constrained firms use trade payables as a substitute for formal financing. According to Wang et al. (2019), the average volume of trade payables for listed non-SOEs in China almost doubled between 2000 and 2013. Accordingly, the redistribution and substitution effects of trade credit may be stronger in China than in developed countries.

The baseline results of this study indicate that firms reduce their use of trade credit (receivables and payables) after short sales deregulation. The large magnitude of short sales also leads firms to grant fewer trade receivables and to depend less on trade payables. Concerning the transmission mechanism, the analysis results suggest that firms' formal financing decreases after short sales deregulation. This decrease discourages firms from providing trade credit. When estimating the dynamic adjustment of trade credit, the results indicate that shortable firms tend to adopt moderate trade credit policies and adjust trade credit to the target level at a lower rate than non-shortable firms.

The results of this study contribute to the literature on trade credit and short sales in several ways. First, the results add to the literature on the economic consequences of short sales (e.g., Gong, 2020). Short sales have a significant impact on the real economy. Gong (2020) suggests that short sales increase firms' financial distress risks and lead financial distress costs to offset the tax benefits of debt. Therefore, shortable firms reduce their optimal financial leverage ratios. Jin et al. (2018) indicate that short sales curb earnings management and encourage managers to be cautious and avoid misconduct. In this case, managers tend to promote accounting conservatism. This work adds to the line of research on the consequences of short sales. Specifically, short sales deregulation, which facilitates the dissemination of negative information, leads investors to become pessimistic and demand higher investment rewards (higher financing costs), and then reduces firms' access to low-cost formal financing. Furthermore, studies suggest that there is a strong relationship between firms' access to formal financing and their use of informal financing (Love et al., 2007; Shang, 2020). On the one hand, when firms obtain less low-cost formal financing, informal financing can be a substitute. On the other hand, when firms have less access to low-cost formal financing, they may not be able to redistribute formal financing via informal financing (Lawrenz & Oberndorfer, 2018; Chen et al., 2019). This study provides evidence for the redistribution effect and demonstrates that firms tend to reduce the amount of trade credit (informal financing) distributed to customers in response to the deterioration of formal financing conditions after short sales deregulation.

Second, we propose short selling as a new factor affecting trade credit. Studies confirm that short selling is a market factor that affects firms' investment and financing decisions, such as innovation (He & Tian, 2015), risk-taking (Ni & Yin, 2020), and financial leverage (Gong, 2020); however, little attention has been paid to trade credit. Trade credit is a crucial source of short-term financing and plays an important role in providing liquidity to firms (especially small ones) in China (Wu et al., 2014). Studies indicate that trade credit is determined by factors such as ownership structure (Wang et al., 2019), market power (Fabbria & Klapper, 2016), and financial crises (Love et al., 2007). In this study, we establish a new link between short sales and trade credit and demonstrate that firms reduce their use of trade credit after short sales deregulation even if trade credit is a crucial short-term financing channel. Consequently, firms lose some short-term financing opportunities, which can reduce their operational efficiency and performance.

Third, we propose that the financing effect of short selling can be used to explain the relationship between short sales and trade credit. Studies suggest that the financing effect associated with short sales affects firms' incentives to avoid taxes (Luo et al., 2020) and the cost of bank loans (Chen et al., 2020). However, none of these studies discuss whether the financing effect of short sales affects the use of trade credit. We fill this research gap and suggest that when short sales deteriorate formal financing conditions, shortable firms offer fewer trade receivables to their customers.

Fourth, we examine the adjustment of trade credit in shortable and non-shortable firms. Studies have long agreed that firms typically have a target level to which they adjust their trade credit (Abdulla et al., 2017). We advance this argument by estimating whether shortable and non-shortable firms adjust their trade credit to the target level at different rates. The results indicate that under the pressure of short selling, shortable firms adopt a moderate trade credit policy and adjust their trade credit at a lower rate than non-shortable firms.

The rest of this paper is organized as follows: section 2 provides a literature review and proposes some hypotheses, section 3 describes the data and methodology, section 4 explains the empirical results, and section 5 comprises the discussion and conclusion.

2. Background, literature review, and hypothesis development

2.1. Policy background

On March 31, 2010, the CSRC launched a short sales deregulation program that allowed 90 stocks to be shortable. On September 16, 2013, the number of shortable stocks increased to 700. On August 9, 2019, it reached 1600 (Feng & Chan, 2016). The Chinese short-selling market has grown rapidly in the last decade. The number of lendable shares (balance) was 0.054 million in 2010 and increased to almost 170 million in 2019.[3] Furthermore, the market capitalization of lendable shares (balance) increased from 11 million yuan in 2010 to almost 14 billion yuan in 2019.

Shortable firms must meet a series of criteria, including a continuous trading record for at least three months, more than 20 million yuan of outstanding shares or at least 800 million yuan in market value, at least 4000 shareholders, and no special treatment (Meng et al., 2020). Moreover, only qualified investors can participate in short selling. Short sellers are required to set up a brokerage account for at least 18 months and hold more than 500,000 yuan in equity before establishing a short-selling account (Chang et al., 2014; Feng & Chan, 2016). Other

[3] The data come from the Shanghai and Shenzhen stock exchanges.

requirements include at least six months of trading experience, a risk tolerance assessment, and an assessment result indicating aggressive investors. Consequently, short sellers are experienced investors whose risk tolerance is much higher than that of ordinary investors. Most Chinese short sellers are not institutional investors (Feng & Chan, 2016), whereas previous studies document that Chinese short sellers are informed and sophisticated traders who can access firms' negative information and incorporate this information into stock prices (Chang et al., 2014).

2.2. Theoretical background

2.2.1. Trade credit-related theories

2.2.1.1. Substitution theory. The relationship between trade credit and formal financing has been widely discussed (e.g., Love et al., 2007). Among the various arguments, the substitution theory states that trade credit serves as a substitute source of finance when formal finance is restricted (Abdulla et al., 2017). Rational firms first use low-cost formal financing to fund their investment opportunities and resort to costly trade credit when they experience financial constraints (Chen et al., 2019). Love et al. (2007) describe a setting in which a financial crisis reduces banks' willingness to take risks and lend even to large firms. In this scenario, bank credit shrinks and trade credit increases to compensate for reduced access to bank credit. Lin and Chou (2015) show that firms have used trade credit to compensate for the shortage of external formal financing after the 2008 financial crisis. Consequently, trade payables serve as a substitute for scarce formal financing. Chen et al. (2019) suggest that high-risk firms have enjoyed greater access to bank credit and reduced reliance on trade credit after the deregulation of bank interest rate ceilings, as such deregulation enables high-risk firms, which may not have received bank credit before, to borrow from banks.

Regarding why firms receive credit from suppliers but experience credit rationing in external markets, studies argue that suppliers have relevant information about borrowing firms' creditworthiness due to their frequent interactions with customers (borrowing firms) and their knowledge of industry prospects (Abdulla et al., 2020). Consequently, informed suppliers may provide liquidity to their financially constrained customers (Wang et al., 2019). However, as financially constrained firms tend to use trade credit as a substitute for formal financing and increase trade payables, they may have a high level of accumulated trade payables. In this scenario, suppliers may have doubts about these firms' abilities to repay their trade payables. Moreover, financially constrained firms are not able to raise sufficient low-cost formal financing in the external market to pay their trade credit, which also decreases suppliers' confidence in firms' paying abilities. Therefore, suppliers may reduce the supply of trade credit as a response, and such firms may have less access to lower trade payables compared with financially flexible firms.

2.2.1.2. Redistribution theory. The redistribution theory is based on the idea that formal financing resources are redistributed from financially strong suppliers to financially weak customers in the form of trade credit (Shang, 2020). Abdulla et al. (2020) demonstrate that some public firms raise equity financing to provide liquidity to their financially constrained customers. Therefore, public firms increase their trade credit supply after initiating equity issuance. Wang et al. (2019) argue that Chinese SOEs have better access to bank credit than non-SOEs. Consequently, non-SOEs, which experience relatively severe bank credit rationing, turn to SOE suppliers and receive more trade payables. Lawrenz and Oberndorfer (2018) document that large firms with better access to formal financing redistribute part of their financing to small firms during tight monetary policy periods. Love et al. (2007) indicate that liquidity runs out during a financial crisis. Consequently, suppliers shut down their redistribution and extend less trade credit to customers.

2.2.1.3. Operational and commercial motives. The operational motive suggests that firms narrow the gap between actual and expected demands by extending trade credit to customers with high market power (Fabbria & Klapper, 2016). The commercial motive indicates that less reputable suppliers provide trade credit to guarantee product quality (Abdulla et al., 2020). However, providing trade credit makes credit management costly for suppliers because trade credit is flexible and the costs of late payments can be transferred from borrowers to lenders (trade credit contagion) (Bastos & Pindado, 2013). Jorion and Zhang (2009) indicate that trade credit borrowers who cannot repay their trade credit in a timely manner may cause financial distress to suppliers. This is especially the case when borrowers suffer external financing problems (e.g., during a financial crisis). Financially constrained borrowers who may not access low-cost formal financing in time are likely to delay their repayment of trade credit, which increases the likelihood of trade credit contagion.

2.2.2. Short-selling-related theories and hypothesis development

Studies provide two competing views to explain the relationship between short sales and the financing ability of firms. One side of the argument posits that short sales improve information transparency and alleviate agency problems, reducing investors' information risks and the risk premium they charge. Therefore, firms' borrowing costs decrease (Hu et al., 2020). Specifically, short sellers are sophisticated in collecting and trading on the basis of firm-related (negative) information, leading stock prices to incorporate such information (Chang et al., 2014). Boehmer and Wu (2013) suggest that more shorting flows alleviate the decrease in stock prices triggered by the announcement of negative earnings surprises. Indeed, short sellers have already uncovered and traded on the basis of negative earnings news, which accelerates the incorporation of negative earnings information into stock prices and allows stock prices to reflect the earnings surprise before its announcement. Therefore, informative stock prices provide a channel to alleviate information asymmetry between investors and managers, reducing the costs of external financing (Hu et al., 2020).

Moreover, short sales serve as a corporate governance mechanism that encourages managers to disclose negative information in a timely manner (Jin et al., 2018). Jin et al. (2018) indicate that more shorting flows impose stronger downward pressure on stock prices. Under the pressure of falling stock prices, managers choose to reveal bad news before an increase in short positions. According to Chen et al. (2020), short sales enable managers to quickly recognize operating losses (negative information), reduce earnings management, and improve information disclosure quality. The high-quality information reported by firms becomes a reliable reference for investors to make decisions (Chen et al., 2020). Thus, the information costs of investors decrease, leading investors to charge a lower information premium (lower interest rate) (e.g., Stiglitz & Weiss, 1981).

According to the substitution theory of trade credit, firms first use low-cost formal financing and then resort to high-cost trade payables when necessary (Wang et al., 2019). Thereby, firms may reduce their trade payables when short selling decreases the cost of formal financing. Concerning trade receivables, the redistribution theory suggests that easing formal financing constraints enables firms to extend more trade credit to customers (Shang, 2020). Accordingly, trade receivables increase when short selling reduces the cost of formal financing. Thus, the following hypotheses are proposed:

H1a. Firms increase their trade receivables after short sales deregulation.

H1b. Firms decrease their trade payables after short sales deregulation.

The other side of the argument posits that short sales aggravate formal financing constraints (e.g., Meng et al., 2020). Short sales, which disseminate negative information about corporate misconduct, create

pessimistic sentiment among investors. Pessimistic investors tend to exaggerate potential risks and underestimate firms' future performance. As a result, they charge a higher premium to compensate for the overestimated risks and losses, which increases firms' financing costs (Karpoff & Lou, 2010). Moreover, short sales create a market panic that distorts a firm's investment plans. Firms may forgo some risky but value-enhancing projects (e.g., research and development activities) under the pressure of short selling. Underinvestment in such valuable projects can harm firms' future performance, which lowers their credit rating and worsens their financing problems (Shi et al., 2021). According to the substitution and redistribution theories, firms may rely more on trade payables and extend fewer trade receivables in response to the financing problems caused by short sales deregulation (Lawrenz & Oberndorfer, 2018). The following hypotheses are therefore proposed:

H2a. Firms decrease their trade receivables after short sales deregulation.

H2b. Firms increase their trade payables after short sales deregulation.

However, as firms may increase trade payables in response to formal financing problems and possibly have a high level of accumulated payables after deregulation, suppliers' confidence in firms' abilities to repay such accumulated payables may decrease. Moreover, financially constrained firms cannot obtain external formal financing to repay trade payables in a timely manner, which increases suppliers' costs related to payment collection. Therefore, suppliers tend to reduce trade credit provided to such financially constrained customers. That is, customers may access fewer trade payables after short sales deregulation.

3. Methodology

3.1. Data

We use a panel dataset of publicly traded firms in the Chinese A-share market over the 2007–2019 period. We first exclude financial firms because of their special financial leverage. Next, we exclude firms with at least a two-year deficit (special treatment firms) and firms with missing governance and financial data. The final sample includes 3,262 firms and 27,607 observations. Moreover, we introduce a matching group based on propensity scores in a robustness test (Section 4.3.3). The matching sample includes 2,895 firms and 22,520 observations. All of the data are collected from the China Stock Market & Accounting Research database (Wu et al., 2014).

3.2. Variable construction and empirical model

3.2.1. Short sales

In this study, we use the time-varying difference-in-differences (DID) method to estimate the effect of short sales deregulation (Meng et al., 2020). Specifically, we introduce a dummy variable, Post, which equals 1 for all years after a firm is included in the shortable list and 0 otherwise, indicating the post-short-selling period. Treated equals 1 if a firm is shortable during the sample period (treatment firm) and 0 otherwise (control firm). According to the time-varying DID method, we mainly focus on the interaction between Post and Treated, which enables us to compare the trade credit of shortable firms with that of non-shortable firms during the post-deregulation period.

Moreover, we introduce continuous variables to measure the effect of the magnitude of short sales on trade credit, as the use of dummy variables may have omitted some continuous characteristics of short selling (e.g., the supply of shortable shares in the market). These characteristics may be crucial in determining the volume of short sales and the strength of the short-selling effect. The continuous variables are Short_volume, defined as the annual number of shares sold by short sellers scaled by the number of shares outstanding at the end of a financial year, and Short_interest, estimated as a firm's annual short interest scaled by the number of shares outstanding at the end of a financial year (Brockman et al., 2020). Short interest is the difference between the annual number of shares sold by short sellers and the annual number of shares repaid by short sellers (Meng et al., 2020). For ease of interpretation, we multiply Short_volume and Short_interest by 100.

3.2.2. Trade credit

Trade credit typically refers to the supply of credit to firms' customers (trade receivables) and the demand for credit from firms' suppliers (trade payables) (Love et al., 2007). Accordingly, we adopt two trade credit proxies, namely the trade payable ratio (Trade_payable), defined as the amount of trade credit a firm receives from suppliers scaled by the cost of goods sold, and the trade receivable ratio (Trade_receivable), measured as the amount of trade credit a firm extends to customers divided by total sales (D'Mello & Toscano, 2020). Trade_receivable (Trade_payable) indicates the percentage of sales (costs) sold (paid) on credit (Love et al., 2007). Moreover, we use net credit (Net_credit), estimated as the difference between trade receivables and payables scaled by total sales (D'Mello & Toscano, 2020). Net credit indicates the trade credit a firm extends to customers relative to the credit it obtains from suppliers (Love et al., 2007). For ease of interpretation, we multiply these trade credit proxies by 100.

3.2.3. Empirical model

As firms become shortable in different years, the treatment years adopted in this study range from 2010 to 2019. Therefore, we adopt the time-varying DID method and include the treatment firm dummy variable (Treated) and the interaction term between the Treated and post-treatment time indicator (Post) (Treated × Post) in our model. According to the time-varying DID method, Post changes with treatment years, and a subscript t (a year indicator) is typically used to reflect this change in Post. Specifically, the following model is used to measure the effect of short sales deregulation on trade credit:

$$Trade\_credit_{i,t} = \beta_1 + \beta_2 Treated_i \times Post_{i,t-1} + \beta_3 Treated_i + \sum \beta_k Control_{i,t-1} + \delta_j + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where i denotes the firm, t reflects the year, and j captures the industry. δ_j and λ_t measure industry and year-fixed effects, which control for unobservable industry and macroeconomic factors. $\varepsilon_{i,t}$ is an error term. Trade_credit represents Trade_receivable, Trade_payable, or Net_credit, defined in Section 3.2.2. Treated and Post are our proxies for short sales, defined in Section 3.2.1. Control is a vector of control variables, including the natural logarithm of total assets (Size); firm age (Age); cash holdings (Cash); cash flow generated during a financial year (Cash_flow); sales growth rate (Growth); profitability (ROA); property, plant, and equipment ratio (PPE); and interest rate (Interest_rate) (Lawrenz & Oberndorfer, 2018; Love et al., 2007; Shang, 2020; Tsuruta, 2015). The control variables are defined in Appendix Table A2. We follow Meng et al. (2020) and lag all of the independent variables by one year. Our coefficient of interest is the coefficient of the interaction term (Treated × Post), β_2, which measures the effect of short sales deregulation on a firm's use of trade credit. Short sales deregulation is expected to increase (decrease) a firm's use of trade credit when β_2 is positive (negative).

Moreover, we use the following model to estimate the effect of the magnitude of short sales on trade credit:

$$Trade\_credit_{i,t} = \beta_1 + \beta_2 Short\_magnitude_{i,t-1} + \sum \beta_k Control_{i,t-1} + \delta_j + \lambda_t + \varepsilon_{i,t}, \quad (2)$$

where Short_magnitude indicates Short_volume or Short_interest, defined in Section 3.2.1. Control includes the control variables used in

Equation (1) and measures related to the impact of margin trading on trade credit (Finance_volume and Finance_interest, defined in Appendix Table A2). The definitions of other symbols are consistent with those in Equation (1).

4. Empirical results

4.1. Summary statistics

Table 1 reports the summary statistics of the main variables. The sample mean value of Treated is 0.569, which indicates that 56.928% of the observations are from the treatment group. The mean values of Trade_receivable and Trade_payable are 26.087 and 31.807, respectively, which suggests that the trade receivables account for 26.087% of total assets and the trade payables account for 31.807% of the cost of goods sold. The mean values of Short_volume and Short_interest are 1.221% and 0.004%, respectively, which are higher than the mean values of 0.100% and 0.0006% reported by Meng et al. (2020). Concerning the control variables, the mean values of Size and Age are 22.088 and 2.753, respectively, which are higher than the mean values of 21.437 and 2.349 mentioned by Wang et al. (2019). The mean value of PPE is 0.228, which is smaller than the mean value of 0.334 reported by Chen et al. (2020). Moreover, the mean value of Cash is 0.186, which is higher than that of 0.166 mentioned by Chen et al. (2020). The mean value of Growth is 0.207, which coincides with that of 0.207 reported by Wang et al. (2019). In panel B, the mean values of Trade_receivable, Trade_payable, and Net_credit in the treatment group (Treated = 1) are lower than those in the control group (Treated = 0), which indicates that shortable firms use less trade credit than non-shortable firms. The *t*-statistics indicate that these differences are statistically significant.

4.2. The effect of short sales on trade credit

Table 2 presents the results of the impact of short sales deregulation on trade credit. In column (1), the dependent variable is Trade_receivable. The coefficient of the interaction term ($Treated_i \times Post_{i,\ t-1}$) is negative and significant (−0.447), indicating that the treatment firms tend to reduce trade receivables extended to their customers after short sales deregulation. This result supports H2a. Specifically, short sales, which send negative information and increase market pessimism, reduce firms' access to formal financing (Meng et al., 2020). Firms with relatively low formal financing may not redistribute liquidity to their customers through trade receivables (Lawrenz & Oberndorfer, 2018). Therefore, trade receivables decrease after deregulation. Economically, shortable firms experience an average marginal decrease of 0.447 in Trade_receivable after short sales deregulation, which accounts for nearly 1.713% of the sample mean of Trade_receivable (0.447/26.087).

Table 2
The effect of short sales deregulation on trade credit.

	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$Treated_i \times Post_{i,t-1}$	-0.447**	-0.563**	-0.312**
	(-2.059)	(-2.062)	(-2.003)
$Treated_i$	-3.320***	-1.241**	-0.905***
	(-6.730)	(-2.314)	(-2.743)
$Age_{i,t-1}$	-4.042***	-1.643***	-2.251***
	(-8.506)	(-3.028)	(-7.198)
$PPE_{i,t-1}$	-12.044***	-13.077***	-6.715***
	(-16.029)	(-11.944)	(-10.612)
$ROA_{i,t-1}$	-8.020***	-22.211***	0.217***
	(-3.526)	(-7.677)	(3.723)
$Growth_{i,t-1}$	-1.380***	-3.851***	0.000
	(-11.951)	(-10.020)	(0.121)
$Cash\_flow_{i,t-1}$	-0.527	-0.071	-0.143
	(-0.729)	(-0.084)	(-0.183)
$Cash_{i,t-1}$	-7.917***	-8.798***	-3.345***
	(-10.773)	(-7.916)	(-5.244)
$Size_{i,t-1}$	-0.285**	1.585***	-1.213***
	(-2.143)	(10.557)	(-14.457)
$Interest\_rate_{i,t-1}$	-2.088***	-1.743***	-1.150***
	(-12.593)	(-8.787)	(-10.008)
Constant	49.393***	12.424***	34.092***
	(11.837)	(2.581)	(5.069)
Year and industry fixed effects	yes	yes	yes
R-squared	0.108	0.111	0.040
Observations	22,424	22,424	22,424

Note: In this table, the results of the impact of short sales deregulation on trade credit are exhibited. Variables are defined in Section 4.2. The fixed effect model (FEM) is used. Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table 1
Summary statistics of main variables.

Panel A

Variables	Obs.	Mean	Median	Std. Dev.	Min	Max
Trade_receivable	27,607	26.087	20.600	21.727	0.830	78.213
Trade_payable	27,607	31.807	26.180	21.780	5.045	84.504
Net_credit	27,607	1.641	0.830	10.897	-27.900	32.730
Short_volume	6793	0.012	0.003	0.012	0	0.127
Short_interest	6793	0.000	0	0.000	0	0.001
Finance_volume	6793	0.743	0.480	0.791	0	1.247
Finance_interest	6793	0.033	0.008	0.114	-0.246	0.564
Post	27,607	0.246	0	0.431	0	1
Treated	27,607	0.569	1	0.495	0	1
Age	27,607	2.753	2.833	0.388	1.386	3.434
PPE	27,607	0.228	0.194	0.170	0.002	0.720
ROA	27,607	0.056	0.053	0.062	-0.206	0.243
Growth	27,607	0.207	0.118	0.523	-0.603	3.724
Cash_flow	27,607	0.007	0.003	0.089	-0.247	0.495
Cash	27,607	0.186	0.149	0.134	0.014	0.699
Size	27,607	22.088	21.912	1.302	19.541	26.053
Interest_rate	27,607	5.730	4.900	0.912	4.900	7.830

Panel B

	Treated = 0	Treated = 1	T-statisics
Trade_receivable	31.216	24.048	23.940***
Trade_payable	34.165	32.829	4.013***
Net_credit	0.032	0.004	21.338***
Obs.	11,891	15,716	

In column (2), the dependent variable is Trade_payable. The coefficient of $Treated_i \times Post_{i,\ t-1}$ is negative and significant (−0.563), which suggests that the treatment firms tend to reduce their use of trade payables after short sales deregulation. This result is consistent with H1b. Specifically, short sales force managers to quickly disclose their negative information, which improves information disclosure quality (Fang et al., 2016). Improved information quality alleviates formal financing problems (Chen et al., 2020). Therefore, firms that prefer low-cost formal financing reduce their use of high-cost trade payables (Chen et al., 2019).

However, when short sales deregulation worsens customers' formal financing conditions, customers tend to use trade credit as a substitute and have a high level of trade payables. The high level of accumulated trade payables may lead to increasing concern about firms' abilities to repay such payables, which hampers suppliers' willingness to provide trade credit. Moreover, firms may not raise formal funds in time to repay trade credit when short sales deteriorate their financing conditions. Therefore, suppliers may be exposed to a high risk of payment collection, which prevents suppliers from extending trade payables. In other words, trade payables decrease after short sales deregulation. Economically, shortable firms experience an average marginal decrease of 0.563 in Trade_payable after short sales deregulation, which accounts for nearly 1.770% of the sample mean of Trade_payable (0.563/31.807).

The dependent variable in column (3) is Net_credit. The coefficient of the interaction term is negative and significant (−0.312), which indicates that the difference between trade receivables and payables decreases significantly after short sales deregulation. Shortable firms reduce both trade receivables and payables after being included in the shortable list, and the decrease in receivables is greater than that in payables.

Moreover, we use our continuous proxies for the magnitude of short sales, Short_volume, and Short_interest and estimate Equation (2). The results are presented in Table 3. In column (1) of panel A, the coefficient of Short_volume is negative and significant (−6.204), indicating that shortable firms that face a large volume of short sales decrease the trade receivables extended to customers. In column (2), the significant negative coefficient of Short_volume (−10.299) also suggests that shortable firms reduce their use of trade payables when they face a large volume of short sales. In column (3), Short_volume has a negative effect on Net_credit, indicating that net trade credit decreases when shortable firms face a large volume of short sales. The explanatory variable in panel B is Short_interest, and the results in panel B are consistent with those in panel A.

Table 3
The effect of short sales magnitude on trade credit.

Panel A			
	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$Short\_volume_{i,t-1}$	-6.204***	-10.299**	-0.711
	(-3.268)	(-2.022)	(-1.638)
Constant	116.232***	138.749	23.560***
	(14.159)	(1.420)	(2.695)
Year and industry fixed effects and controls	yes	yes	yes
R-squared	0.421	0.023	0.867
Observations	6,755	6,755	6,755
Panel B			
	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$Short\_interest_{i,t-1}$	-3.958**	-6.203***	-1.002*
	(-2.181)	(-3.012)	(-1.691)
Constant	93.080***	49.509***	23.970***
	(16.342)	(6.910)	(2.657)
Year and industry fixed effects and controls	yes	yes	yes
R-squared	0.496	0.349	0.866
Observations	6,755	6,755	6,755

Note: In this table, the results of the impact of short sales magnitude on trade credit are presented. Short_volume and Short_interest are defined in Section 3.2.1. The definitions of other variables are consistent with those in Table 2. FEM is used. Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

4.3. Robustness tests

4.3.1. Additional control variables

The endogeneity problem arises when some control variables that simultaneously affect trade credit and short sales are missing. Accordingly, in this section, we introduce additional control variables. Specifically, we control for the ratio of shares owned by top managers (Manager_share) because the share ownership plan may lead managers to make value-enhancing decisions (Meng et al., 2020). Valuable firms are more likely to access formal financing and extend trade credit and less likely to attract short sellers than less valuable firms (Box et al., 2018). The debt-to-total-assets ratio (Leverage) is controlled because highly leveraged firms may face bank credit rationing and resort to trade credit. Meanwhile, financial leverage increases liquidity risk, which is positively related to short positions (Gong, 2020; Hyun, 2021). The ratio of short-term bank loans (Short_bankloan) is included because short-term bank loans have substitution effects on trade credit (Kling et al., 2014). However, a high level of short-term bank loans increases firms' financial burden and the threat of short selling (Gong, 2020). The SOE indicator (SOEs) and Tobin's q (Q) are included because SOEs in China have a strong tendency to redistribute their liquidity to small non-SOEs through trade credit (Chen et al., 2020; Wang et al., 2019) and SOEs with severe information problems face a high magnitude of short sales (Meng et al., 2020). Similarly, studies document a negative effect of Tobin's q on trade credit (Chen et al., 2019; Garcia-Appendini & Montoriol-Garriga, 2013); meanwhile, Tobin's q, which is associated with firm value, affects the extent of short sales' threats (Chen et al., 2018). In general, the proxies mentioned above affect trade credit and short sales simultaneously, so controlling for these proxies mitigates potential simultaneity issues. The results reported in Tables 4 and 5 are consistent with those in Tables 2 and 3 when considering additional

Table 4
Additional control variables (short sales deregulation).

	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$Treated_i \times Post_{i,t-1}$	-0.400*	-0.616**	-0.283*
	(-1.849)	(-2.254)	(-1.938)
$Treated_i$	-2.964***	-1.207**	-0.835***
	(-5.889)	(-2.298)	(-2.784)
$Leverage_{i,t-1}$	-7.388***	7.003***	-14.243***
	(-11.150)	(15.700)	(-32.464)
$Manager\_share_{i,t-1}$	2.599***	0.893	1.081**
	(3.154)	(0.919)	(2.039)
$SOEs_{i,t-1}$	-2.206***	-0.720*	-1.297***
	(-5.964)	(-1.679)	(-5.473)
$Q_{i,t-1}$	-0.086	-0.147	0.298***
	(-0.844)	(-1.636)	(4.355)
$Short\_bankloan_{i,t-1}$	6.169***	-8.592***	8.008***
	(6.147)	(-7.368)	(13.271)
Constant	34.007***	15.118***	18.565***
	(7.566)	(2.979)	(6.652)
Year and industry fixed effects and control variables in Equation (1)	yes	yes	yes
R-squared	0.123	0.113	0.074
Observations	22,423	22,423	22,423

Note: In this table, additional control variables are included. Additional control variables are defined in Section 4.3.1. The definitions of other variables are consistent with those in Table 2. FEM is used. Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table 5
Additional control variables (short sales magnitude).

Panel A			
	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$Short\_volume_{i,t-1}$	-6.712***	-6.807*	-1.361**
	(-3.466)	(-1.668)	(-2.006)
Constant	71.761***	138.417**	13.111***
	(7.402)	(1.962)	(3.748)
Year and industry fixed effects and control variables in Equation (2) and Section 4.3.1	yes	yes	yes
R-squared	0.430	0.035	0.422
Observations	6,755	6,755	6,755
Panel B			
	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$Short\_interest_{i,t-1}$	-4.911***	-4.379**	-0.011*
	(-2.711)	(-2.194)	(-1.673)
Constant	56.272***	86.060***	0.135
	(7.920)	(10.471)	(1.342)
Year and industry fixed effects and control variables in Equation (2) and Section 4.3.1	yes	yes	yes
R-squared	0.505	0.389	0.871
Observations	6,755	6,755	6,755

Note: In this table, additional control variables are included. Additional control variables are defined in Section 4.3.1. The definitions of other variables are consistent with those in Table 3. FEM is used. Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

control variables.

4.3.2. Dynamic model

As a general rule for DID, the treatment and control firms must follow a parallel trend before short sales deregulation. In this section, we adopt the dynamic model to estimate the existence of parallel trends before short sales deregulation. We introduce six time indicators: Before (t) (t = 1, 2), which equals 1 for year t (t = 1, 2) before a firm is included in the shortable list and 0 otherwise, and After (t) (t = 1 to 3), which equals 1 for year t (t = 1 to 3) after a firm is included in the shortable list and 0 otherwise. After4 equals 1 for three or more years after a firm has become shortable and 0 otherwise. Next, we include the interaction term between Treated and these time indicators in Equation (1). The regression results are presented in Table 6. The coefficients of $Treated_i \times Before1_i$ and $Treated_i \times Before2_i$ are not significant, indicating that the trade credit characteristics of the treatment firms are not significantly different from those of the control firms and that the treatment and control firms generally follow a parallel trend before short sales deregulation. Moreover, in columns (1) and (2), the coefficients of $Treated_i \times After2_i$ and $Treated_i \times After4_i$ are significant and negative, as are the coefficients of $Treated_i \times After3_i$ and $Treated_i \times After4_i$ in column (3). These results indicate that the use of trade credit by the treatment firms continuously declines after short sales deregulation. In general, the dynamic model shows a parallel trend between the treatment and control firms before deregulation and a continued decline in trade credit in the treatment firms after deregulation.

4.3.3. Matching sample regression

In the analyses above, we estimate the impact of short sales deregulation on trade credit using the full sample of 27,607 observations and find a significant change in trade credit after the treatment firms are included in the shortable list. However, this change in trade credit may be caused by some unobservable firm and market characteristics rather than by short sales deregulation. In this section, we adopt a matching

Table 6
Dynamic model.

	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$Treated_i \times Before2_i$	0.188	-0.374	0.000
	(0.326)	(-0.738)	(.)
$Treated_i \times Before1_i$	0.150	-0.827	0.214
	(0.258)	(-1.626)	(1.115)
$Treated_i \times After1_i$	-0.572	-1.400**	0.003
	(-0.843)	(-2.327)	(0.016)
$Treated_i \times After2_i$	-1.183*	-1.724***	-0.207
	(-1.663)	(-2.773)	(-0.935)
$Treated_i \times After3_i$	-1.073	-1.505**	-0.403*
	(-1.452)	(-2.301)	(-1.767)
$Treated_i \times After4_i$	-1.544***	-2.684***	-0.501**
	(-2.813)	(-5.593)	(-2.200)
$Treated_i$	-1.431***	0.010	0.000
	(-3.938)	(0.032)	(.)
Constant	133.104***	22.488***	34.258***
	(32.464)	(6.397)	(8.312)
Year and industry fixed effects and control variables in Equation (1)	yes	yes	yes
R-squared	0.411	0.269	0.755
Observations	22,424	22,424	22,424

Note: In this table, the dynamic model is adopted. Before(t) and After(t) are defined in Section 4.3.2. The definitions of other variables are consistent with those in Table 2. FEM is used. Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

process in which matching firms are selected based on various firm and market characteristics (matching variables), including market capitalization (Market_value), ratio of net income to total equity (ROE), state ownership indicator (SOEs), stock return (Stock_return), stock return volatility (Volatility), stock turnover ratio (Turnover), trade payable ratio (Trade_payable), trade receivable ratio (Trade_receivable), and the control variables used in Equation (1) (Meng et al., 2020). We regress a dummy variable that equals 1 if a firm is shortable during the sample period and 0 otherwise on these matching variables (to estimate the propensity scores) and match a treatment firm with a control firm without replacement according to the estimated propensity scores (one-to-one matching). As a result, the matching firms generally possess characteristics (measured by these matching variables) of the treatment firms. Appendix Table A1 reports insignificant differences in the mean of most of the matching variables between the treatment and matching groups. The differences in the mean of Size, ROA, Market value, Cash flow, and SOEs are significant after matching, but the *t*-statistics of these differences decrease, which also suggests an efficient matching process (Meng et al., 2020). The matching process generates a sample of 2895 firms and 22,520 observations. The maximum difference between the

Table 7
Matching sample regression.

	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$Treated_i \times Post_{i,t-1}$	-0.802**	-0.922**	-0.291*
	(-2.425)	(-2.135)	(-1.794)
$Treated_i$	-2.282***	-0.645	-0.388
	(-3.746)	(-1.054)	(-1.120)
Constant	67.077***	19.880**	41.930***
	(8.893)	(2.325)	(6.183)
Year and industry fixed effects and control variables in Equation (1)	yes	yes	yes
R-squared	0.133	0.123	0.045
Observations	18,999	18,999	18,999

Note: In this table, the results of matching sample regression are presented. The definitions of variables are consistent with those in Table 2. FEM is used. Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

propensity scores of the treatment and control firms is 0.009. The regression results shown in Table 7 are consistent with those presented in Table 2, indicating that the decrease in trade credit is mainly caused by short sales deregulation rather than by unobservable firm and market characteristics (matching variables).

4.4. Further analyses

4.4.1. Transmission mechanism

In this section, we discuss a possible transmission mechanism through which short sales affect firms' trade credit—that is, formal financing conditions. Specifically, when short sales reduce formal financing problems, firms will distribute more formal financing to customers through trade receivables, whereas when short sales deteriorate firms' financing conditions, firms' willingness to distribute financing and extend trade receivables will decrease. Moreover, when firms can access low formal financing, they use trade payables as a substitute, whereas when formal financing problems are mitigated, firms first resort to low-cost formal financing and reduce the use of trade payables.

Accordingly, in this section, we investigate whether firms redistribute financial resources through trade receivables and whether there is a substitution of formal financing and trade payables after short sales deregulation. Specifically, we add the interaction term between Post, Treated, and the ratio of short-term bank loans obtained in a year to total assets (New_shortloan in Appendix Table A2), $\text{New\_shortloan}_{i,\ t-1} \times \text{Treated}_i \times \text{Post}_{i,\ t-1}$, to Equation (1). A positive relationship between $\text{New\_shortloan}_{i,\ t-1} \times \text{Treated}_i \times \text{Post}_{i,\ t-1}$ and Trade_receivable indicates that the more (less) short-term bank loans firms obtain after short sales deregulation, the higher (lower) the trade receivables firms extend to customers. That is, firms experience a redistribution effect (of receivables) after deregulation. Conversely, a negative relationship between $\text{New\_shortloan}_{i,\ t-1} \times \text{Treated}_i \times \text{Post}_{i,\ t-1}$ and Trade_payable suggests that the more (less) short-term bank loans firms can obtain after short sales deregulation, the lower (higher) the trade payables firms receive from suppliers. In other words, there is a substitution effect (of payables) after deregulation. Short-term bank loans are selected because trade credit is a source of firms' short-term financing and is typically used as a substitute for short-term bank loans (Kling et al., 2014).

The regression results are presented in Table 8. In column (1) of panel A, the dependent variable is Trade_receivable. The coefficient of $\text{New\_shortloan}_{i,\ t-1} \times \text{Treated}_i \times \text{Post}_{i,\ t-1}$ is positive and significant (16.430), indicating the existence of the redistribution effect after short sales deregulation. Specifically, the treatment firms extend more trade receivables if they receive more bank credit after short sales deregulation, but they reduce their trade receivables if bank financing decreases after deregulation.

The dependent variable in column (2) of panel A is Trade_payable. The coefficient of $\text{New\_shortloan}_{i,\ t-1} \times \text{Treated}_i \times \text{Post}_{i,\ t-1}$ is negative and significant (−7.446), indicating that the substitution effect of trade payables increases after deregulation. Specifically, the treatment firms use more trade payables if they access less bank credit after short sales deregulation. Trade payables are thus used as a substitute for reduced formal bank financing. Conversely, the treatment firms resort to low-cost formal bank financing and reduce high-cost trade payables if they can borrow more from banks after deregulation.

Moreover, we use new bank loans (both short-term and long-term) and new financing received by issuing corporate bonds in a year to estimate a firm's ability to access formal financing. We include the interaction term between Post, Treated, and the sum of new bank loans and bond financing obtained by a firm in a year scaled by total assets ($\widehat{\textit{New\_formalloan}}_{i,\ t-1}$), $\widehat{\textit{New\_formalloan}}_{i,\ t-1} \times \text{Treated}_i \times \text{Post}_{i,\ t-1}$, in Equation (1). The results in panel B of Table 8 also show the redistribution effect of trade receivables and the substitution effect of trade payables after short sales deregulation. In addition, short sales deregulation affects both equity and debt financing conditions. Therefore, for a robustness check, we use a variable for new debt financing and equity financing obtained in a year scaled by total assets ($\widehat{\textit{New\_externalfinance}}$) as a measure of formal financing conditions and regress our trade credit variables on $\widehat{\textit{New\_externalfinance}}_{i,\ t-1} \times \text{Treated}_i \times \text{Post}_{i,\ t-1}$. The results in panel C of Table 8 are consistent with those in panels A and B.

Table 8
Transmission mechanism.

Panel A

	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$\widehat{\textit{New\_shortloan}}_{i,t-1}$	2.316	2.930	2.744**
	(1.072)	(1.432)	(2.274)
$\widehat{\textit{New\_shortloan}}_{i,t-1} \times \text{Treated}_i \times \text{Post}_{i,t-1}$	16.430***	-7.446*	6.513***
	(2.762)	(-1.879)	(3.185)
Constant	151.865***	66.054***	77.430***
	(43.633)	(21.223)	(44.093)
Year and industry fixed effects, Treated_i, $\text{Treated}_i \times \text{Post}_{i,t-1}$, $(\text{Post} \times \widehat{\textit{New\_shortloan}})_{i,t-1}$, $\text{Treated}_i \times \widehat{\textit{New\_shortloan}}_{i,t-1}$, and controls	yes	yes	yes
R-squared	0.416	0.284	0.323
Observations	22,424	22,424	22,424

Panel B

	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$\widehat{\textit{New\_formalloan}}_{i,t-1}$	-2.592	-3.056*	0.908*
	(-1.525)	(-1.875)	(1.777)
$\widehat{\textit{New\_formalloan}}_{i,t-1} \times \text{Treated}_i \times \text{Post}_{i,t-1}$	13.546***	-7.441***	0.912*
	(2.950)	(-4.421)	(1.759)
Constant	134.934***	5.766	19.188***
	(28.008)	(0.646)	(3.199)
Year and industry fixed effects, Treated_i, $\text{Treated}_i \times \text{Post}_{i,t-1}$, $(\text{Post} \times \widehat{\textit{New\_formalloan}})_{i,t-1}$, $\text{Treated}_i \times \widehat{\textit{New\_formalloan}}_{i,t-1}$, and controls	yes	yes	yes
R-squared	0.323	0.107	0.053
Observations	22,424	22,424	22,424

Panel C

	(1)	(2)	(3)
	Trade_receivable	Trade_payable	Net_credit
$\widehat{\textit{New\_externalfinance}}_{i,t-1}$	-0.194	-1.040	0.401
	(-0.150)	(-0.746)	(0.696)
$\widehat{\textit{New\_externalfinance}}_{i,t-1} \times \text{Treated}_i \times \text{Post}_{i,t-1}$	6.474*	-5.108***	1.039*
	(1.695)	(-3.297)	(1.659)
Constant	134.482***	5.917	18.568***
	(28.961)	(0.662)	(3.428)
Year and industry fixed effects, Treated_i, $\text{Treated}_i \times \text{Post}_{i,t-1}$, $(\text{Post} \times \widehat{\textit{New\_externalfinance}})_{i,t-1}$, $\text{Treated}_i \times \widehat{\textit{New\_externalfinance}}_{i,t-1}$, and controls	yes	yes	yes
R-squared	0.330	0.107	0.047
Observations	22,424	22,424	22,424

Note: In this table, the transmission mechanism is examined using FEM. New_shortloan, New_formalloan, and New_externalfinance are defined in Section 4.4.1. The definitions of other variables are consistent with those in Table 2. Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

4.4.2. Short sales and formal financing

So far, we have demonstrated that the redistribution and substitution effects exist when short sales change the formal financing conditions of

firms. A further question is whether short sales improve or worsen shortable firms' formal financing conditions. Scholars have yet to reach a consensus on this question (Hu et al., 2020; Meng et al., 2020). On the one hand, short sales improve the information environment, reducing the information premium (financing costs) investors charge (Hu et al., 2020). On the other hand, short sales disseminate negative information about firms and increase investor pessimism, worsening external financing conditions (Meng et al., 2020). Accordingly, it is necessary to discuss the formal financing conditions of firms after short sales deregulation.

In this section, we regress our measures of external financing (New_shortloan, New_formalloan, and New_externalfinance defined in Section 4.4.1) on Treated and the interaction term between Post and Treated to estimate the external financing conditions of firms after short sales deregulation. A negative (positive) coefficient of the interaction term indicates that firms' financing conditions worsen (improve) after short sales deregulation. The control variables used in this regression include those in Equation (1) and additional control variables that affect firms' debt and equity financing (Leverage, Manager_share, SOEs, Q, and Risk defined in Appendix Table A2) (Chen et al., 2019). The results in columns (1) to (3) of Table 9 show that the coefficients of $\text{Treated}_i \times \text{Post}_{i,\ t\text{-}1}$ are negative and significant (–0.003, –0.011, and –0.017, respectively), indicating that shortable firms' access to new bank credit and other sources of external financing decreases after deregulation. This finding suggests that short sales worsen firms' formal financing conditions.

For a robustness test, we follow Meng et al. (2020) and compare firms' investment–cash flow sensitivity before and after short sales deregulation. A higher level of investment–cash flow sensitivity typically suggests greater financial constraints (Meng et al., 2020). The model is as follows:

$$\begin{aligned} Investment_{i,t} = {} & \beta_1 Investment_{i,t-1} + \beta_2 Investment^2_{i,t-1} + \beta_3 Cash\_flow_{i,t-1} \\ & + \beta_4 Cash\_flow_{i,t-1} \times Post_{i,t-1} \times Treated_i + \beta_5 \left(Cash\_flow \times Post\right)_{i,t-1} \\ & + \beta_6 Cash\_flow_{i,t-1} \times Treated_i + \beta_7\ Post_{i,t-1} \times Treated_i + \beta_8\ Treated_i \\ & + \beta_9 Sales_{i,t-1} + \beta_{10} Leverage^2_{i,t-1} + \delta_i + \lambda_t + \varepsilon_{i,t}, \end{aligned} \tag{3}$$

where i denotes the firm and t reflects the year, δ_i and λ_t are firm and year-fixed effects, and $\varepsilon_{i,t}$ is the error term. Investment, Sales, and Leverage are firms' investment, sales, and debt-to-total-assets ratios, respectively, and are defined in Appendix Table A2. The definitions of other symbols are consistent with those in Equation (1). Equation (3) is estimated using the systematic generalized method of moments (systematic GMM) (Meng et al., 2020). The result in column (4) of Table 9 shows that the coefficient of the interaction term $(Cash\_flow_{i,t-1} \times Post_{i,t-1} \times Treated_i)$ is positive and significant (0.311), suggesting that firms' investment–cash flow sensitivity increases and that corporate investment depends more on internal cash flow than on external financing after short sales deregulation. The reason for this is that firms' access to external formal financing decreases after deregulation.

Shortable firms that receive less formal financing tend to reduce the trade receivables extended to customers after deregulation. Meanwhile, firms that have less access to formal financing after deregulation may use trade payables as a substitute, but the increase in trade payables may lead suppliers to show concern about firms' payment abilities, which reduces suppliers' willingness to provide trade credit. Therefore, trade payables decrease after short sales deregulation.

4.4.3. Changes in firms' sales after short sales deregulation

Typically, customers tend to make transactions with reputable firms. However, short sales reveal negative information about firms, which can harm a firm's reputation, making customers less willing to transact with them. In this scenario, firms will lose market share and suffer a decrease in sales. The decrease in sales will also result in a decrease in trade receivables. In this section, we estimate whether firms' sales decrease after short sales deregulation. We regress the sales to total assets ratio (Sales) (or the sales growth ratio, Growth) on $\text{Treated}_i \times \text{Post}_{i,\ t\text{-}1}$, Treated, the control variables in Equation (1), and the following control variables: advertising expenses (Advertisement), the Herfindahl index of sales for the industries (HHI_sales), the standard deviation of sales in a firm's primary industry over the past four years divided by the industry's average sales for these years (Std_sales), and the difference in working capital between the current year and the previous year divided by the working capital of the previous year (Change_workingcap) (Cao & Li, 2015). The regression results are presented in Table 10. The coefficients of $\text{Treated}_i \times \text{Post}_{i,\ t\text{-}1}$ are negative and significant (–0.020 and –0.069),

Table 9
The impact of short sales deregulation on formal financing.

	(1)	(2)	(3)	(4)
	New_shortloan	New_formalloan	New_externalfinance	Investment
$\text{Treated}_i \times \text{Post}_{i,t\text{-}1}$	-0.003***	-0.011***	-0.017***	0.001
	(-2.741)	(-3.640)	(-4.980)	(0.089)
Treated_i	0.003***	0.003	0.009***	0.003
	(2.814)	(1.215)	(3.167)	(0.169)
$\text{Cash\_flow}_{i,t\text{-}1}$				0.312***
				(3.244)
$\text{Cash\_flow}_{i,t\text{-}1} \times \text{Treated}_i \times \text{Post}_{i,t\text{-}1}$				0.311**
				(2.290)
Constant	0.000	-0.085**	0.167***	
	(0.036)	(-2.497)	(4.338)	
Industry fixed effect	yes	yes	yes	
Firm fixed effect				yes
Year fixed effect and controls	yes	yes	yes	yes
$\text{Investment}_{i,t\text{-}1}$, $\text{Investment}^2_{i,t\text{-}1}$, $\text{Cash\_flow}_{i,t\text{-}1} \times \text{Teated}_i$, $(\text{Cash\_flow} \times \text{Post})_{i,t\text{-}1}$				yes
R-squared	0.036	0.360	0.358	
AR(1)				0.000
AR(2)				0.417
Hansen test: Prob > chi2				0.224
Wald chi^2				2784.01***
Number of instruments				79
Number of firms				3014
Observations	22,424	22,424	22,424	22,424

Note: In this table, the results of the impact of short sales deregulation on formal financing are exhibited. Variables are defined in Section 4.4.2. FEM is used in columns (1) to (3). Systematic GMM is used in column (4). Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

Table 10
Changes in firms' sales after short sales deregulation.

	(1)	(2)
	Sales	Growth
$Treated_i \times Post_{i,t-1}$	-0.020*	-0.069***
	(-1.784)	(-7.395)
$Treated_i$	-0.003	0.103***
	(-0.335)	(11.757)
Constant	-0.990***	1.423***
	(-10.208)	(10.173)
Year and industry fixed effects and controls	yes	yes
R-squared	0.274	0.053
Observations	22,886	22,886

Note: In this table, the results of changes in firms' sales after short sales deregulation are exhibited. Variables are defined in Section 4.4.3. FEM is used. Robust z-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

which indicates that firms experience a decrease in sales (sales growth) after short sales deregulation. The decrease in sales (sales growth) is a possible reason for the aforementioned decrease in trade receivables after deregulation.

4.4.4. Speed of adjustment to target trade credit

Our analyses above focus on a stable level of trade credit, but according to Abdulla et al. (2017), firms typically have target trade credit and tend to adjust their current trade credit when it deviates from the target. In this section, we concentrate on the dynamic adjustment of trade credit and explore whether the speed of adjustment to target trade credit differs between shortable and non-shortable firms. Following Abdulla et al. (2017), we adopt the partial adjustment model below:

$$\Delta Trade\_credit_{i,t} = \beta_1 + \delta\left(Trade\_credit^*_{i,t} - Trade\_credit_{i,t-1}\right) + \varepsilon_{i,t}, \quad (4)$$

where $\Delta Trade\_credit_{i,t}$ is the change in trade credit from year $t-1$ to t ($\triangle$Trade_receivable$_{i,\ t}$, $\triangle$Trade_payable$_{i,\ t}$, and $\triangle$Net_credit$_{i,\ t}$). $Trade\_credit_{i,t-1}$ is our trade credit proxies lagged by one year. $Trade\_credit^*_{i,t}$ is the target trade credit level (Trade_receivable$_{i,\ t}$*, Trade_payable$_{i,\ t}$*, and Net_credit$_{i,\ t}$*) estimated using the following equation:

$$Trade\_credit_{i,t} = \beta_1 + \sum \beta_k Control_{i,t} + \varepsilon_{i,t}, \quad (5)$$

where Control is a vector of the control variables, including current asset ratio (Current), short-term debt ratio (Short_debt), negative sales growth (Negative_growth), ln (1+Age), ln (1+Age),[2] Size, Cash_flow, and Cash (Abdulla et al., 2017). Therefore, $Trade\_credit^*_{i,t}$ is the estimated value of Equation (5), that is, $\widehat{Trade\_credit_{i,t}}$. We then estimate Equation (4), in which our coefficient of interest is the coefficient of $Trade\_credit^*_{i,t} - Trade\_credit_{i,t-1}(\delta)$, as it measures the speed of adjustment to target trade credit. δ ranges from 0 to 1, and a higher value of δ indicates a higher speed of adjustment (Faulkender et al., 2012).

In Table 11, the coefficients of $Trade\_credit^*_{i,t} - Trade\_credit_{i,t-1}$ (δ) are positive and significant, suggesting that firms seek to adjust their trade credit level to the target one (Abdulla et al., 2017). We also compare the trade credit adjustment speeds of shortable (columns (1) and (3), Table 11) and non-shortable (columns (2) and (4), Table 11) firms. The coefficients of $Trade\_receivable^*_{i,t} - Trade\_receivable_{i,t-1}$ in columns (1) and (3) are 0.066 and 0.050, respectively, which are lower than the coefficients of 0.076 and 0.077 in columns (2) and (4). This result suggests that shortable firms adjust trade receivables more slowly than non-shortable firms. This difference in adjustment speeds between shortable and non-shortable firms is significant based on the F-statistics of the Chow tests. The results hold when considering trade payables and net credit in panels B and C of Table 11. The baseline results in Section 4.2 indicate that short sales prevent shortable firms from accessing trade credit. The results in this section suggest that shortable firms do not change their current trade credit level dramatically and that their trade credit adjustment speed is slow.

5. Conclusion and discussion

In this study, we investigate the effect of short sales on trade credit. The results demonstrate that both the deregulation and the magnitude of

Table 11
Speed of adjustment to target trade credit.

Panel A	(1)	(2)	F-stat of Chow test	(3)	(4)	F-stat of Chow test
	Treated = 1	Treated = 0	(P-value)	Post × Treated = 1	Post × Treated = 0	(P-value)
$Trade\_receivable_{i,t}$*-$Trade\_receivable_{i,t-1}$	0.066***	0.076***	117.570	0.050***	0.077***	32.790
	(19.821)	(19.358)	(0.000)	(10.967)	(25.312)	(0.000)
Constant	0.363***	0.642***		0.138	0.581***	
	(5.004)	(6.214)		(1.367)	(7.860)	
Observations	14,715	11,190		6,790	19,115	
R-squared	0.026	0.032		0.017	0.032	

Panel B	(1)	(2)	F-stat of Chow test	(3)	(4)	F-stat of Chow test
	Treated = 1	Treated = 0	(P-value)	Post × Treated = 1	Post × Treated = 0	(P-value)
$Trade\_payable_{i,t}$*- $Trade\_payable_{i,t-1}$	0.153***	0.167***	62.340	0.062***	0.099***	1.610
	(32.777)	(30.218)	(0.000)	(14.379)	(36.045)	(0.204)
Constant	0.816***	1.290***		0.962***	0.939***	
	(6.703)	(8.523)		(8.468)	(12.759)	
Observations	14,715	11,190		6,790	19,115	
R-squared	0.068	0.075		0.030	0.064	

Panel C	(1)	(2)	F-stat of Chow test	(3)	(4)	F-stat of Chow test
	Treated = 1	Treated = 0	(P-value)	Post × Treated = 1	Post × Treated = 0	(P-value)
$Net\_credit_{i,t}$*- $Net\_credit_{i,t-1}$	0.132***	0.138***	3.770	0.121***	0.139***	152.16
	(33.263)	(30.254)	(0.052)	(22.441)	(38.811)	(0.000)
Constant	-0.090**	-0.172***		-0.200***	-0.108***	
	(-2.353)	(-3.563)		(-3.980)	(-2.929)	
Observations	14,715	11,190		6,790	19,115	
R-squared	0.070	0.076		0.069	0.073	

Note: In this table, the results of adjustment speed are presented. Variables are defined in Section 4.4.4. The ordinary least squares method is used. Robust t-statistics are in parentheses. ***p<0.01, **p<0.05, *p<0.1.

short sales are negatively related to trade receivables and payables. Firms' access to formal financing decreases after short sales deregulation, which is accompanied by a decrease in their ability to redistribute financing through trade credit. Moreover, firms dynamically adjust their trade credit level, and shortable firms adjust their trade credit level to the target level more slowly than non-shortable firms.

Our results have several implications. First, firms must adopt a policy of multiple sources of financing. When suppliers reduce their trade payables, customers who rely heavily on trade payables will experience a liquidity shortage. To avoid such shortages, they must look for alternative financing channels. Second, short sales not only affect shortable firms' stock market performance but also their operating performance. Short sales reduce firms' ability to take risks and change their financing and investment policies, leading them to forgo some profitable risky projects and crucial financing channels. These behaviors will worsen firms' operating performance. Third, as stock market mechanisms affect the real economy, it is necessary to consider the broader economic consequences of adopting new stock trading policies. On March 31, 2010, the CSRC allowed 90 firms in the Chinese A-share market to be shortable. This new policy changed firms' access to formal financing and trade credit policies, which can influence their market share and performance. These economic consequences must be estimated.

The study also has limitations. For instance, we do not include years after the COVID-19 pandemic due to limited data availability. The relationship between short sales and trade credit may have changed during the pandemic, as the pandemic increased economic uncertainty.

Appendix

Table A1
PSM results

	Treated means	Control means	T-C	t-statistics	Treated means	Control means	T-C	t-statistics
	Before				After			
ROE	0.076	0.051	0.025	2.012**	0.076	0.068	0.008	0.645
Growth	0.218	0.191	0.027	4.251***	0.218	0.204	0.014	1.705
Age	2.738	2.754	-0.016	-2.401***	2.738	2.739	-0.001	-0.169
Stock_return	0.001	0.000	0.001	27.425***	0.001	0.001	0.000	0
Volatility	0.031	0.030	0.001	6.224***	0.031	0.031	0.000	0
Turnover	0.400	0.318	0.082	5.766***	0.400	0.392	0.008	0.444
Trade_receivable	27.134	33.483	-6.349	-1.603*	27.134	27.356	-0.222	-0.050
Trade_payable	31.252	32.365	-1.113	-3.738***	31.252	30.800	0.452	1.281
Cash	0.189	0.192	-0.003	-1.667**	0.189	0.190	-0.001	-0.484
PPE	0.224	0.220	0.004	1.933**	0.224	0.223	0.001	0.409
Interest	5.780	5.670	0.110	5.660***	5.780	5.760	0.020	1.029
Size	22.559	21.547	1.012	65.302***	22.559	21.771	0.788	43.029 ***
ROA	0.063	0.047	0.016	21.529***	0.063	0.055	0.008	14.998***
Cash_flow	0.019	0.002	0.017	13.400***	0.019	0.005	0.014	11.157***
Market_value	22.469	22.040	0.429	12.604***	22.469	22.122	0.347	10.192***
SOEs	0.495	0.352	0.143	22.430***	0.495	0.390	0.105	16.350***

Note: In this table, the character mean difference between treatment and control groups before and after PSM is presented. ***p<0.01, **p<0.05, *p<0.1.

Table A2
The variable definition

Variables	Definitions
Trade_receivable	The amount of trade credit a firm extends to customers divided by total sales
Trade_payable	The amount of trade credit a firm receives from suppliers scaled by the cost of goods sold
Net_credit	The difference between trade receivables and payables scaled by total sales
Short_volume	The annual number of shares sold by short sellers scaled by the number of shares outstanding at the end of a financial year
Short_interest	The annual short interests scaled by the number of shares outstanding at the end of a financial year
Finance_volume	The annual margin volume scaled by market capitalization at the end of a financial year
Finance_interest	The annual margin interests scaled by market capitalization at the end of a financial year
Post	Equals 1 for all years after a firm is included in the shortable list and 0 otherwise
Treated	Equals 1 if a firm is shortable during the sample period and 0 otherwise
Age	The natural logarithm of one plus the firm age
PPE	The ratio of the property, plant, and equipment value to total assets
ROA	The ratio of EBIT to total assets
Growth	The difference between sales at the end of a financial year and sales measured as the beginning of the financial year scaled by the beginning sales level
Cash_flow	The ratio of the operating cash flow to total assets
Cash	The ratio of the cash balance to total assets
Size	The natural logarithm of total assets
Interest_rate	The three-year borrowing interest rate faced by a firm multiplied by 100
Market_value	The natural logarithm of the market value of total shares
ROE	The ratio of net incomes to total equities
Leverage	The total debt to total assets ratio
Manager_share	The ratio of shares owned by top managers to total shares
SOEs	Equals 1 if the firm is controlled by central or local governments and 0 otherwise
Q	The sum of the market value of equity and book value of liability divided by the book value of total assets
Volatility	The standard deviation of the daily stock return in a financial year
Turnover	The average daily stock turnover ratio in a financial year
Stock_return	The average daily stock return in a financial year
Negative_growth	Equals 1 if the annual sales growth is positive and 0 otherwise
Short_debt	The ratio of short-term debt to total debt

(*continued on next page*)

Table A2 (*continued*)

Variables	Definitions
Before(t) (t = 1, 2)	Equals 1 for year t before a firm is included in the shortable list and 0 otherwise
After(t) (t = 1 to 3)	Equals 1 for year t after a firm is included in the shortable list and 0 otherwise
After4	Equals 1 for three or more years after a firm has become shortable and 0 otherwise
Current	The ratio of current asset to total assets
Short_bankloan	The ratio of short-term bank loans to total assets
New_shortloan	The ratio of short-term bank loans obtained by a firm in a year to total assets
New_formalloan	The sum of new bank loans and bond financing obtained by a firm in a year scaled by total assets
New_externalfinance	The new debt and equity financing obtained by a firm in a year scaled by total assets
Advertisement	The logarithm of advertising expenses
HHI_sales	The Herfindahl index of sales in the industries
Std_sales	The standard deviation of sales in a firm's primary industry over the past four years divided by the industry's average sales for these years
Change_workingcap	The difference in working capital between the current year and the previous year divided by the working capital of the previous year
Risk	The natural logarithm of the standard deviation of stock returns for the last twelve months
Investment	The sum of the leasing expense and net purchase of PPE scaled by total assets
Sales	The ratio of sales to total assets
Pilot(t)	An interaction between Post(t) and Treated. Post(t) indicates a dummy variable that equals 1 for the current and t years after a firm is included in the shortable list and 0 otherwise (t = 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9).
△Trade_receivable	The change in trade receivables from year t-1 to t
△Trade_payable	The change in trade payables from year t-1 to t
△Net_credit	The change in the difference between trade receivables and payables from year t-1 to t
Trade_receivable*	The estimated target level of trade receivables
Trade_payable*	The estimated target level of trade payables
Net_credit*	The estimated target level of net trade credit

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