Bank Credit Losses and Bailout in Real-Sector Network

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Abstract

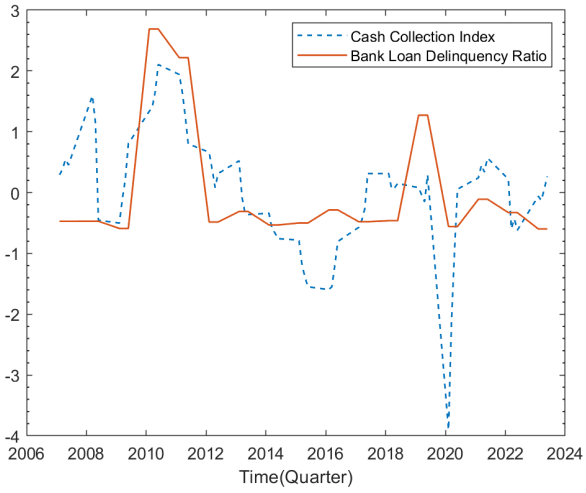
The paper explores the intricacies of inter-firm bailout behavior by analyzing the roles of firms' input-output distributions and trade credit statuses. It investigates how these factors influence bailout incentives, abilities, as well as their impact on bailout outcomes. The incentive for inter-firm bailouts is rooted in the net benefits obtained from interest incentives relative to the costs incurred in providing bailouts. A firm's ability to engage in a bailout is dependent on the liquidity conditions of firms within the "feasible bailout set." The characteristics of firms' input-output distributions further influence the success of bailouts. Firms with a more pronounced right-skewed and higher mean input-output distribution are more likely to be successfully bailed out, thereby reducing the risk of bank loan defaults. Additionally, these firms are more likely to participate in bailing out other firms, as their probability of being included in the feasible bailout set of other firms is higher.

Keywords: Inter-firm bailout, Input-output distribution, Bank loan delinquency, Trade credit.

1. Introduction

With the continuous development of global financial and real sectors, not only has the scale of bank credit been continuously increasing, but also lending between non-financial institutions has gradually become an important source of external financing for firms. Taking China as an example, from the perspective of accounts receivable alone, the amount of lending between Chinese non-financial companies has exceeded the total amount of bank loans. Over the past 20 years, this ratio has increased from around 0.8 to about 1.2. The total amount of accounts receivable of non-financial enterprises accounts for nearly 30% of the total liabilities. These two indicators are higher in most OECD countries such as the United States. The scale of trade credit in the United States even reaches three times that of bank credit. The undeniable fact across the world is that lending between non-financial enterprises will play an increasingly pivotal role in corporate financing, significantly impacting financial risk and economic development.

Another noteworthy economic phenomenon is that, according to the survey questionnaire of the People's Bank of China and the statistics on bank loans in Figure 1, there is a significant positive correlation between cash collection situations and bank loan delinquency rates. Generally, we would expect that as a company's financial situation deteriorates, its cash collection situation worsens and the bank loan delinquency rate increases, implying a negative correlation between these two variables. However, data suggest the reverse. This anomaly may partly reflect the presence of inter-firm liquidity insurance mechanisms in China, which also exists in many other countries. For example, Cuñat (2007) suggests that suppliers can provide customers



Data sources: Cash Collection Index is from Entrepreneur Survey by the People's Bank of China and Bank Loan Delinquency Ratio is form CSMAR. The data has been standardized.
NOTES: Cash Collection Index reflects the cash collection situation of firms' accounts receivable. The coefficient of correlation between the cash collection index and the bank loan delinquency rate is 0.54, significant at the 1% level.

Figure 1: Cash Collection Index and Bank Loan Delinquency Ratio

liquidity insurance in the UK when facing a moderate decline in asset growth rates (a 30% decrease), firms tend to exhibit higher levels of trade credit. Similar stories happens in France, Sweden and the USA (Boissay and Gropp, 2013; Franks and Sussman, 2005; Reischer, 2024). Given the mutual interest in survival shared by suppliers and their customers, firms may tolerate delayed payments and even extend additional trade credit to financially distressed counterparts (Meltzer, 1960; Nilsen, 2002; Garcia-Appendini and Montoriol-Garriga, 2013; Carbó-

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valverde et al., 2016). Consequently, liquidity shocks are absorbed by other firms in the supply chain rather than being transmitted to the banking system. Although the risk transmission caused by trade credit and liquidity insurance mechanisms has been a hot topic, there is little literature on the specific characteristics of inter-firm bailout behaviors, their relationship with firms' input-output and trade credit status, and the impact on bank loan losses. In this paper, we show a series of characteristics of inter-firm lending behavior during liquidity tightness, and its significant impact on bank loans.

To fill this literature gap, our study aims to analyze and examine the characteristics of inter-firm bailout behavior and the impacts on bank loan losses. Given the widespread difficulties in trade credit recovery (see Cuñat, 2007; Garcia-Appendini and Montoriol-Garriga, 2013; Franks and Sussman, 2005) and the stricter penalties for bank loan defaults, during financial distress, there is bailout behavior among non-financial firms in the private sector. This bailout involves the redistribution of liquidity through inter-firm lending, thereby alleviating liquidity constraints and serving as a liquidity insurance across firms (Cuñat, 2007; Wilner, 2000; Reischer, 2024), reducing loan defaults, and avoiding bank penalties and bankruptcy liquidation. This type of bailout behavior is related to the input-output relationship and trade credit status between firms.

The characteristics of the inter-firm lending differ from the inter-bank lending. Inter-bank bailout actions contain risk contagion, thereby reducing overall financial system losses. These bailouts in the inter-bank network are beneficial given the existence of the cost of default (Rogers and Veraart, 2013). However, there are significant differences between the financial system and real-sector firms network: there is a "mutually dependent" relationship between firms with close input-output connections. If a neighboring firm in the input-output network goes bankrupt, the other firm not only faces the loss of trade credit but must also find alternative upstream and downstream partners, which disrupts production (Altinoglu, 2021). The bankruptcy of one party can severely impact the production and operations of the other, increasing future operating costs. Successful rescues of distressed firms allow creditor firms to avoid these losses and the participating companies will also reap high interest income. But engaging in bailout actions incurs costs such as gathering debtor information, leading to free-rider problems (Rogers and Veraart, 2013), which can affect bailout outcomes. Introducing inter-firm lending interest rates can mitigate free-riding issues to some extent. Distressed firms could incentivize other companies to provide bailout funds by raising interest rates (Cuñat, 2007). In that case, liquidity-abundant firms have the incentive to bail out neighboring distressed firms, creating a mechanism of risk sharing.

Our research primarily addresses two questions: First, what are the factors that influence the incentive and ability of firms to bailout each other? Second, will the input-output distribution of firms affect their bailout behaviors and thus impact the bank loans losses? We first explore the specific bailout mechanism through theoretical analysis, and analyze the mechanism of bailout behavior and the influencing factors of bailout incentive and bailout ability. Then, we construct proxies for firm bailout incentive and bailout ability according to the theory. Our empirical evidence is consistent with our theoretical predictions, showing that the increase in bailout incentive and bailout ability can significantly reduce bank loan losses. At the same time, the skewness and mean of the input-output distribution of firms also have a significant impact on bank loan losses.

This study contributes to the literature in the following four aspects. First, previous research has mainly focused on the existence of inter-firm liquidity insurance and the mitigating effect of liquidity insurance on shocks. To the best of our knowledge, this paper is the first to analyze which factors affect the incentive and ability of inter-firm bailout through the input-output distribution of firms. Second, we deepen the discussion on how input-output distribution affects bailout outcomes and bank losses by comparing the bailout characteristics of firms with different input-output distribution features. Third, our study identifies the features of firms that play a key role in inter-firm bailout (including both suppliers and demanders of bailout funds), providing new insights for systemic risk management and highlighting the importance of systemic important entities. Fourth, previous literature, starting with the liquidity shocks in the bank system, has focused on examining the amplification effect of input-output networks on real economic variables, as well as the complementary and substitutive relationship between trade credit and bank credit (Acemoglu et al., 2016; Altinoglu, 2021; Bigio and La'O, 2020; Luo, 2020; Boissay and Gropp, 2013; Jacobson and Schedvin, 2015; Reischer, 2024; Cuñat, 2007; Afrouzi and Bhattarai, 2023). We use the firm-level data and extend the topic to explore how trade loans and output linkages between real economy enterprises affect the losses of bank loans, that is, how the interactions within the real economy contribute to the risks associated with bank lending.

The remainder of the paper is organized as follows. Section 2 introduces the related literature and background. Section 3 builds the model and provides the theoretical analysis. Section 4 describes the data set and summary statistics. Section 5 presents the empirical results. Section 6 concludes with further discussions on relevant policy recommendations.

2. Related literature and background

2.1. The characteristics of trade credit

A significant amount of research is dedicated to analyzing the role of trade credit in providing external financing to firms. There is some evidence suggesting that trade creditors may have an advantage over banks in providing credit to enterprises, especially for companies with lower levels of information transparency. One reason is that suppliers may act as "relationship lenders," possessing more information through daily trade interactions (McMillan and Woodruff, 1999; Uchida et al., 2013). Smith (1987) and Biais and Gollier (1997) find that suppliers can obtain information about customer quality that banks cannot. Cuñat (2007) also mentiones that trade suppliers might have an advantage in enforcing unsecured debt contracts. Demirguc-Kunt and Maksimovic (2001) further emphasize that information about corporate customers has potential

value. Sellers act based on this information to provide credit under conditions that banks cannot offer. When suppliers' customers are rationed in the banking loan market, this advantage enables suppliers to provide more credit than banks. Another paper indicates that smaller suppliers provide more trade credit to reputable borrowers as a mechanism to signal product quality (Klapper et al., 2012). Cook (1999) and Ono (2001) suggest that the informational advantage suppliers have in financing opaque firms might imply complementarity between trade credit and bank loans. Another perspective posits that trade credit is not a complement to bank loans but a substitute, as the overall cost of trade credit is lower (Meltzer, 1960; Ramey, 1992; Marotta, 1997; Uesugi and Yamashiro, 2004). Contrarily, Cuñat (2007) provides evidence that trade loans include liquidity insurance premiums and default costs, resulting in higher implicit interest rates, which may be related to the secondary priority status of trade debt for many countries (Cuñat, 2007; Garcia-Appendini and Montoriol-Garriga, 2013; Franks and Sussman, 2005).

2.2. *Risk contagion and liquidity insurance among real firms*

A growing body of literature has investigated the risk contagion and liquidity insurance among real firms. Due to the inconsistent timing of purchases and sales revenue realization in the real economy, enterprises along the supply chain often engage in credit sales and prepayments to improve turnover efficiency. A company may simultaneously borrow from suppliers and provide credit to downstream customers, naturally increasing the company's default risk (McMillan and Woodruff, 1999; Fabbri and Klapper, 2016). Therefore, firms facing customer payment defaults may encounter liquidity problems, leading to delays in payments to their suppliers. This default chain may spread through the supply chain. Kiyotaki and Moore (1997) also argue that debt chains between firms can amplify shocks, forming default chains. Jacobson and Schedvin (2015) empirically demonstrate significant trade credit losses suffered by trade creditors due to trade debtor bankruptcy, with creditor bankruptcy risk increasing with the magnitude of losses. Moreover, Kiyotaki and Moore (2001) explain that the contagion of debt defaults may be halted by a sufficiently liquid enterprise. And Luo (2020) distinguishes between the effects of large and small financial shocks. Under large shocks, trade credit amplifies the propagation of financial distress, whereas, under small shocks, trade credit mitigates the propagation of illiquidity contagion. These two conclusions are also the same as a characteristic of trade credit networks consistent with views of Acemoglu et al. (2015) on financial network stability. Building on this, Cuñat (2007) proposes a mechanism where upstream suppliers provide liquidity insurance to downstream firms and explaines the reason behind the rising implicit interest rates in trade credit. Raddatz (2010) provides indirect evidence of amplification mechanisms related to trade credit chains. He uses input-output matrix data to show that industries with broader trade credit relationships have higher cash flow correlation. Boissay and Gropp (2013), Garcia-Appendini and Montoriol-Garriga (2013) and Carbó-valverde et al. (2016) provide empirical evidence for liquidity insurance and inter-firm crisis bailout. They find that distressed firms rely more on inter-firm lending when facing liquidity shocks, and cash-rich firms increase credit provision to distressed firms, a phenomenon particularly evident among SMEs with low bank credit availability.

2.3. *Input-output relationship*

Studies on production networks focus more on the impact of production networks on economic output fluctuations. Acemoglu et al. (2012) constructs a comprehensive general equilibrium model to study the shock amplification mechanism within production networks, positing that idiosyncratic shocks in one sector can propagate through the production network, causing spillovers via higher-order interconnections (cascade effects). Bigio and La'O (2020), using a static multi-sector framework, further investigate how sectoral distortions and productivity shocks amplify to the aggregate level through total factor productivity and wages. Additionally, from an empirical perspective, Acemoglu et al. (2016) analyze the relationship between sectoral shocks and total factor productivity (TFP) at the industry level based on theoretical models. Afrouzi and Bhattarai (2023) study the dynamic impact of production networks on inflation and economic growth. Building on this, De Graeve and Schneider (2023) use a FAVAR model to identify the transmission sequence of shocks across different sectors, confirming that sectoral shocks are amplified at the aggregate level through strong input-output network effects and resonances between industries. Altinoglu (2021) further comprehensively analyze the risk amplification effects of production networks and trade credit networks, deeply examining the impact of input-output relationships and trade credit channels on upstream and downstream firms. These studies provide both theoretical and empirical evidence for the mutual dependence between firms through shock transmission and amplification arising from input-output and trade credit linkages.

2.4. *Research on private sector Bailout*

As far as we know, research on private sector bailouts has mainly focused on the financial system, with less emphasis on bailouts in the real economy, but studies on private sector bailouts in the financial system have implications for bailout behavior in the real economy. Leitner (2005) argues that the optimal network provides the best trade-off between risk-sharing and systemic collapse. Networks are generated through project investments, with the success of these projects depending on the investments of agents and their direct contacts. Therefore, agents are motivated to form connections to increase the chances of project success. Rogers and Veraart (2013) believe that banks can prevent default cascades through mergers. However, in their paper, mergers do not need to be incentive-compatible with individual bank shareholders, nor do they discuss the characteristics of bailout sets or which types of banks are likely to bail out others or be bailed out. Duffie et al. (2007) consider a bargaining model where internal bailouts are accomplished through contracts rather than a central planner. They show that, under the condition of prohibiting bargaining failure, private bailouts achieved in a network of three banks are effective within a limited scope. Bernard et al. (2022) consider both

private and central bank bailouts, primarily analyzing bailout motivations and free-rider problems, using a game theory perspective to examine when banks are incentivized to help each other rather than relying on the central bank.

3. Theoretical Analysis

In the real economy network, if an exogenous shock causes firm i to fall into financial distress, the bankruptcy of firm i, due to bankruptcy costs, will result in trade credit creditors bearing trade credit losses. These creditors will then need to re-establish input-output relationships with other firms that can replace firm i. These spillover losses from the bankruptcy of firm i will motivate other firms in the supply chain to bail out the bankrupt firm, possibly by extending trade credit terms or providing additional credit. In the absence of bailout costs, bailing out distressed firms would always be an absolute dominant strategy. However, in a complex network with bailout costs, the free-rider problem becomes a critical factor influencing the outcome of bailouts. This problem may lead to an equilibrium where either several firms jointly undertake the bailout or all of them stand by, expecting others to take action. In the absence of other participation incentives, the equilibrium is likely to shift towards a "free rider" equilibrium. This situation closely resembles a "sunspots" bank run issue, where expectations and coordination problems among firms exacerbate the financial distress. We posit that in the absence of additional participation incentives, firms that are not experiencing financial distress will not intervene to bailout distressed firms. To investigate the distinct features of inter-firm bailout behavior, we introduce inter-firm lending interest rates to eliminate the free rider problem.

Suppose a recurring single-period static economy, economic conditions reset periodically one-period model. There are n firms in the economy, the cash flow of each firm in the economy can be represented as:

$$\pi_i = p_i x_i - \sum_{j=1}^{n} p_j x_{ij} + \sum_{j=1}^{n} \tau_{ij} - \tau_i - B_i + \epsilon_i, \tag{1}$$

where π_i represents the net cash flow of firm i, x_i is firm i's sales, x_{ij} is firm j's sales to firm i, τ_{ij} is firm i's account payable to firm j, $p_i x_i - \sum_{j=1}^{n} p_j x_{ij}$ is the operating profit of firm i, $\sum_{j=1}^{n} \tau_{ij}$ is the original trade debt of firm i, τ_i is the original trade claims of firm i, and B_i is the maturing bank debt of the firm, ϵ_i represents the exogenous shock on firm i. When $\pi_i < 0$, the bank loan will incur a loss $-\pi_i + \sigma_i$[1]. And we assume that the bank will not provide additional bank credit to firms in distress and the firm has no existing assets or equities that its solvency solely relies on the cash flow generated from current production activities. The different shocks on firms and differences in remaining cash flows provide possibilities for liquidity coordination among firms.

Regarding the concept of trade credit interest rates, we adhere to the research approach established by Cuñat (2007). Specifically, due to the inevitability of companies providing liquidity insurance to each other through trade credit during liquidity shocks, the net providers of trade credit cannot be certain that the net demanders will not exploit trade credit to avoid bankruptcy in the future. As a result, the interest on trade credit always includes an insurance premium. Moreover, this premium increases as the financial condition of the trade credit demanders deteriorates or as the likelihood of liquidity shocks rises. In our model, to simplify the analysis, we assume that all shocks are exogenous. Firms establish trade credit agreements based on their input-output relationships, and no malicious defaults[2] occur between firms. As a result, under normal circumstances, the trade credit interest rates between firms remain relatively low. However, when some firms experience shocks, they seek additional trade credit to avoid bankruptcy (such as delaying trade loan repayments or reducing the repayment amounts). At this point, firms reprice this newly extended trade credit, which is reflected in an increase in liquidity insurance premiums and a rise in interest rates (Cuñat, 2007).

Without loss of generality, pre-existing trade credit is assumed to be interest-free. However, once firm i encounters financial distress, acquiring new trade debt incurs interest charges[3], with a defined cap on the interest rate r_i^{max} that firm i is willing to bear, which can be regarded as a participation incentive to avoid free rider problem. Without loss of generality, we assume that in the absence of exogenous shocks, firms always ensure positive profits and can smoothly avoid debt default through debt rollover and swaps. Therefore, the trade debt incurred during financial distress can be regarded as perpetual debt.

Based on the assumption above, the interest celling r_i^{max} the firm i can provide should satisfy the following conditions:

$$NPV_i = \frac{\bar{\pi}_i - (-\pi_i \times r_i^{max})}{\bar{r}_i} = 0, \tag{2}$$

where NPV_i represents the difference between firm i's continuous operating capability and the present value of the borrowed trade debt, $\bar{\pi}_i$ and $\bar{r}_i$ are the net cash flow under normal operations ($\epsilon_i = 0$) and the discount rate corresponding to the associated risk[4], respectively. $-\pi_i$ is the funding gap during a financial crisis, which is also the total amount of trade debt that firm i needs to borrow. Solving equation (2), we obtain

$$r_i^{max} = \frac{\bar{\pi}_i}{-\pi_i}. \tag{3}$$

In alignment with economic intuition, the maximum interest rate that firm i can sustain is contingent upon two critical factors: the firm's operating profitability during normalcy and its current existing funding gap.

[1] To simplify the analysis, we assume that bankruptcy cost is σ_i, which is exogenous.

[2] The scenario in which a firm is fully capable of repaying trade credit on time and in full, yet deliberately defaults

[3] This is a streamlined operation and the results do not rely on this assumption. Our aim is merely to highlight the fact that during periods of financial distress, trade credit providers face additional risks due to the increased probability of insolvency in distressed firms, thereby necessitating higher interest rates, as Cuñat (2007); Reischer (2024) mentioned.

[4] Without loss of generality, we assume the $\bar{r}_i = \bar{r}$ for any firm i, so we henceforth drop the subscript i of $\bar{r}_i$.

3.1. Bailout Incentive

For firm j with excess liquidity, when the benefits of providing financial bailout exceed the bailout costs, firm j has an incentive to bailout distressed firm i.

DEFINITION 1. *Let d_{ij} represent the sum of the elements in matrix $\boldsymbol{Q}$[5] at row i, column j and row j, column i, encompassing all direct and indirect input-output linkages between firms i and j. d_{ij}^{max} denotes the max value of d_{ij} for each i.*

$$\begin{aligned}\boldsymbol{Q} &= \boldsymbol{P} + \boldsymbol{P}^2 + \cdots \\ &= (\boldsymbol{I} - \boldsymbol{P})^{-1} - \boldsymbol{I} \\ &= \begin{bmatrix} q_{11} & \cdots & q_{1n} \\ \vdots & \ddots & \vdots \\ q_{n1} & \cdots & q_{nn} \end{bmatrix} \\ d_{ij} &= q_{ij} + q_{ji}\end{aligned}$$

A larger d_{ij} indicates a closer connection between the two firms within the real economy network. We consider both the direct and indirect connections because empirical results in Jacobson and Schedvin (2015) show that the allocation of liquidity goes beyond bilateral relationship and even exists between two firms without any direct business relationship. This phenomenon can manifest in various forms. The first resembles the trade credit defaults described in Kiyotaki and Moore (2001) case. When Firm A falls into financial distress, it defaults on trade credit owed to Firm B, with which it has a direct relationship. If Firm B is also facing tight financial conditions, it may choose to default on trade credit owed to Firm C, with which it has a direct connection but which is not directly linked to Firm A. The effect is akin to Firm C providing credit support to Firm A directly. Another scenario involves Firm A directly seeking bailout funds from firms with greater liquidity. This search for bailout may extend outward, based on input-output linkages, and may be realized through direct loans or guarantees, akin to the entrusted loans common in China described by Allen et al. (2019).

DEFINITION 2. *Let set $\boldsymbol{A}$ represent the set of all firms with an incentive to provide bailout fund, which is pinned down by the upper bound d_{ij}^{max} and lower bound d_{ij}^{amin}*[6].

DEFINITION 3. *Let α_{ij} denote the disposable bailout cost rate. We assume that the bailout cost rate is a function of the degree of input-output linkage between firms i and j. Assume this bailout cost function satisfies the property: $\alpha_{ij} = f(d_{ij})$, $f' < 0$, $f'' > 0$, $\lim_{d_{ij}\to 0} f(d_{ij}) = +\infty$ and $\lim_{d_{ij}\to +\infty} f(d_{ij}) = 0$.*

Bailout costs can be understood as the necessary expenditure incurred by firms with surplus liquidity when deciding whether to bail out a distressed firm. This includes the costs associated with producing information, such as evaluating the distressed firm's ability to survive and assessing its future cash flow conditions. Intuitively, the closer the input-output linkages between two firms, the lower the degree of information asymmetry and the smaller the moral hazard issue they face. The searching, negotiation, or monitoring costs are lower, leading to lower costs of inter-firm lending and two firms that have no direct or indirect linkages will rarely provide bailout fund when one of them falls into financial distress. This assumption is consistent with the spirits of Smith (1987); Biais and Gollier (1997); McMillan and Woodruff (1999) and Uchida et al. (2013). For example, when the creditor provides the bailout fund, repaying a loan is akin to the firm in distress pledging its future cash flows as collateral and others with close trade ties have a better and special knowledge of the debtor's situation, resulting in lower information production costs.

Assume the bailout loan contract is information-sensitive. When a firm with favorable future operating conditions and a small current funding gap has high collateral value, the creditor's incentive to produce information decreases. Conversely, low collateral value strengthens the creditor's incentive to produce information, increasing bailout costs. And suppose the firm i's interest rate celling is not a common knowledge. Therefore, other firms cannot judge the exact size of set $\mathbf{A}$. The factors determining whether a firm j will engage in bailout are only the expected interest income from the bailout funds and the bailout costs. More specifically, we have

PROPOSITION 1. *The incentive compatibility condition of bailout cost can be articulated as:*

$$\forall j \in \boldsymbol{A}, r_i > \alpha_{ij}\bar{r},$$

where r_i denotes the bankruptcy-risk-adjusted required return rate for firm j providing a trade loan to firm i based on firm i's belief, which is a private information.

Proof. See Appendix A

The implication of proposition 1 is that only when the interest incentive offered by firm i surpasses the bailout cost rate, will firm j provide additional bailout fund to firm i. Assume that the creditor has complete bargaining power. The bailout incentive can exist only if the maximum interest rate firm i can offer is not less than the required interest rate of firm j, $r_i^{max} \geq r_i$. As shown in Figure 2, the incentive compatibility condition holds only when $\mathbf{A}'$ is a subset of $\mathbf{A}$.

COROLLARY 1. *When the incentive compatibility condition is met, the firm i's interest rate celling should satisfy the condition:*

$$r_i^{max} > \max_{j\in\boldsymbol{A}} \alpha_{ij}\bar{r}.$$

Corollary 1 characterizes the incentive compatibility condition relative to the interest rate celling. As illustrated in Figure 2, as the capacity to bear debt increases, r_i^{max} rises to $\hat{r}_i^{max}$ accordingly and the bailout threshold, represented by d_{ij}^{amin}, will shift to $\hat{d}_{ij}^{amin}$, and the maximum feasible bailout is replaced by set $\mathbf{A}^*$ and encompass more firms which are willing to bailout the distressed firm i so that the distressed firm i has higher probability of survival.

[5] The matrix $\mathbf{P}$ is the direct input-output linkages between firms and the elements in $\mathbf{Q}$, d_{ij}, represent the overall input-output linkages between firm i and firm j.

[6] The d_{ij} of the last firm that is willing to provide bailout fund.

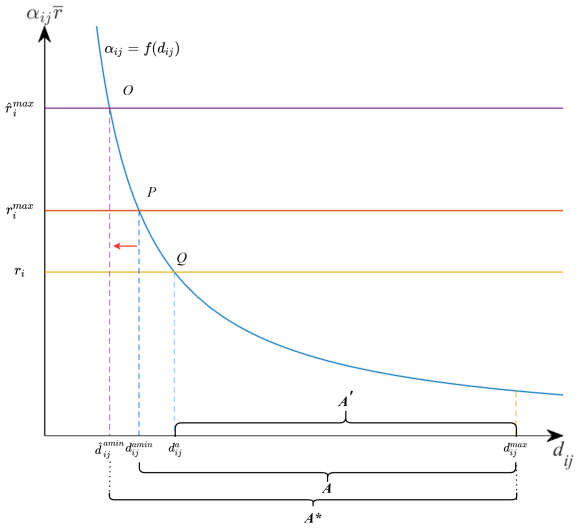


Figure 2: Feasible bailout set for firm i

Corollary 1 and equation (3) imply that a firm's enhanced operating profitability generates high interest celling and augments other firms' incentive to provide bailout funds during crises, thereby mitigating the risk of failure. Conversely, a substantial current funding gap exacerbates future debt repayment burdens, which constrains the firm's ability to obtain bailout funds during crises and escalates the likelihood of eventual bankruptcy.

3.2. Bailout Ability

Only when the sum of the remaining liquidity of all firms with a incentive to bailout (included in set **A**) is greater than the gap of distressed firm i plus the total bailout costs, we can say that firms in set **A** have the bailout ability. Therefore, we have

PROPOSITION 2. *Firms in **A** are able to bail out the distressed firm i if and only if*

$$\sum_{j\in A}(1-\alpha_{ij})\pi_j + \pi_i \geq 0,$$

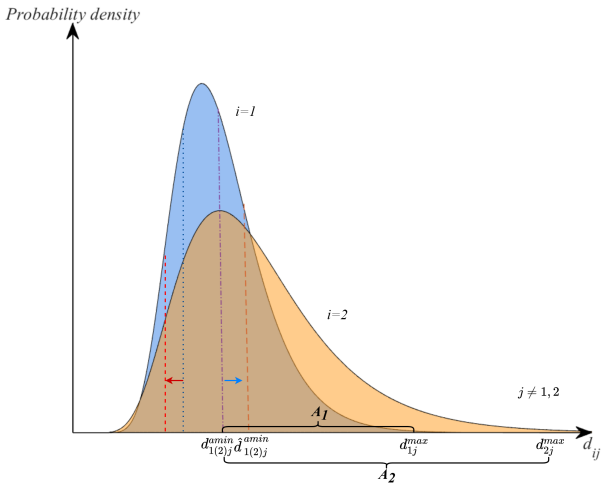
where π_j is the remaining liquidity of firm j, π_i is the funding gap of firm i, which is negative.

The bailout ability depends on three factors: the scale of remaining liquidity of firms in set **A** other than the financially distressed firm i, the size of the funding gap of firm i, and the sum of bailout cost.

3.3. Bailout outcome

Since conditions in proposition 1 and 2 do not always align, it is essential to consider both dimensions when evaluating bailout outcomes. It is obvious that the maximum amount of available bailout funds to firm i is positively correlated with the bailout incentive (r_i^{max}) that pins down the lower bound of the maximum feasible bailout set. But it is ambiguous how the distribution of the funds and the structure of the total bailout cost affect the bailout ability, thereby affecting the bailout outcome.

Analyzing the distribution of funds and the structure of bailout cost is essentially analyzing the distribution of distressed firm i's d_{ij}. We use a simple example as shown in Figure 3 to clarify this issue. Without loss of generality, we assume that firm 1 and firm 2 have the same r_i^{max} and the same bailout cost rate function, meaning that their lower bounds of feasible bailout sets are identical.



The mean of the distribution for firm 1 is smaller than that of firm 2, and the skewness of firm 2's distribution is greater. A_1 denotes the maximum feasible bailout set for firm 1, while A_2 denotes the maximum feasible bailout set for firm 2.

Figure 3: Feasible bailout set and firm distribution

As shown in Figure 3, if the distribution is more right-skewed and has a larger mean, more firms have a closer connection with the distressed firm and the maximum feasible bailout set includes more firms, thus increasing the probability of successfully bailing out the distressed firm.

As depicted by the blue arrow in Figure 3, on the right side of the probability density peak, as r_i^{max} diminishes, the lower bound of A shifts from $d_{1(2)j}^{amin}$ to $\hat{d}_{1(2)j}^{amin}$, and a larger mass of firms is excluded from firm 1's maximum feasible bailout set compared to firm 2, due to firm 1's lower mean and skewness of distribution. Therefore, else being equal, a marginal change in r_i^{max}, or the collective bailout incentive for firm i, has a stronger impact on the bailout outcome if the distressed firm i has a lower mean and skewness of d_{ij} distribution.

The above analysis generates the following two testable hypothesis.

HYPOTHESIS 1. *Firms with a higher mean and more right-skewed distribution of closeness to other firms are more likely to be bailed out and thus, have a lower probability of bank loan default.*

HYPOTHESIS 2. *The marginal effect of a change in bailout incentive is stronger for firms with a lower-mean and more left-skewed distribution of closeness to other firms.*

Furthermore, the incentive and ability for inter-firm bailouts are influenced by the firms' positions within the trade credit net-

work. This influence can be gauged through metrics like the net stock of trade debt, as suggested by Klapper et al. (2012). For instance, higher net trade debt indicates a stronger capability to utilize funds from other firms and a greater ability to acquire additional trade credit. The trade credit network is shaped not only by the input-output network but also by factors like bargaining power between firms and supply and demand elasticity. Thus, the information in net trade debt about inter-firm bailouts is not fully captured by input-output relationships. Additionally, because bank loans are prioritized over accounts payable and default penalties are higher for bank loans than for trade credit (Franks and Sussman, 2005; Garcia-Appendini and Montoriol-Garriga, 2013), existing trade credit can cushion bank loans in some cases. Compared to inter-firm lending, penalties for defaulting on bank loans are more severe, facilitating bankruptcy proceedings. Therefore, to ensure business continuity, financially distressed firms are more incentivized to seek inter-firm bailouts to avoid bankruptcy. Therefore, we have the following hypothesis:

HYPOTHESIS 3. *Firms which have a higher level of trade debt have a lower probability of bank loan default.*

4. Data and variables

4.1. Data

Our data come from two sources. The first of these is the CSMAR database, which contains firm characteristics including financial information and the specific situation of firm's bank loans. The second source of data is the Chinese Time Series Input-Output Database constructed by Zhang et al. (2021), which contains time series of input-output tables for the 18 major industries in China. The data frequency is annual.

Our data set allows us to combine firm's financial information with industry-level input-output relationship. This is critical in measuring the inter-firm bailout incentive and ability. Constrained by the limitations of input-output tables, we use industry-level input-output data as a representative of the firm's input-output data assuming the listed firms can effectively represent the industry's input-output dynamics. While contingent upon the uniform input-output distribution within each industry, this can also to some extent signify the relative interplay of input-output distribution among firms. Our final sample covers 757 listed firms with bank loan overdue and extension data over the period 2000 to 2018, which represents around 19% of total listed firms in China on average over the sample period. The data frequency is semiannual.

4.2. Variables and summary statistics

The dependent variables used throughout this section are the default amount of firm i's bank loans. We uses the sum of overdue amount and extension amount of firm i's bank loans as indicator of the default amount of firm i's bank loans. The previous analysis assumes that banks do not provide additional bank credit to distressed firms, but in reality loan extension is a common phenomenon. The extension of bank loans can be seen as another form of overdue, equivalent to the bank taking the risk of loan default. Therefore, this paper uses the sum of overdue loan amount and extension amount as the measure of bank risk, which is more consistent with the results of theoretical analysis.

Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Bank Loan Loss	17.373	2.092	0.000	22.687
Bailout Incentive	-0.001	0.095	-5.893	0.914
Bailout Ability	-0.040	0.078	-0.437	0.076
Skewness	0.004	0.003	0.000	0.016
Mean	0.004	0.005	0.000	0.046
Net Trade Debt	0.004	0.061	-0.090	2.501
Ddue	19.255	1.584	0.693	25.134
cfo	0.094	1.078	-17.997	34.166
sale	19.513	2.079	7.125	26.883
lnasset	20.927	1.345	12.270	27.337
cash	0.099	0.108	-0.047	0.998
ROA	-0.066	0.283	-4.175	0.774
type	0.817	0.449	0	2
d_{ij}	0.005	0.006	0.000	0.043
Skewness raw	2.177	0.732	0.030	3.658
Mean raw	0.003	0.002	0.000	0.011

NOTES: The descriptive statistical data in the table have been appropriately adjusted for the dimensionality of variables and logarithmic adjustments have been made to sales and total assets and the extreme outliers have been removed. The Skewness raw and Mean raw are the raw, unscaled skewness and mean.The ownership indicator (type) is defined as follows: it takes the value 0 if the firm is private, 1 if the firm is state-owned, 2 if the firm is a Sino-foreign joint venture.

In accordance with the theoretical analysis, we categorize the independent variables of interest in four types: (1) bailout incentive indicator, (2) bailout ability indicator, (3) the distribution of input-output relationships [7], and (4) trade credit indicator.

Bailout incentive: Corollary 1 and equation (3) suggest that firms have incentive to bail out distressed firm i if their normal profits is large relative to current liquidity level and the bailout cost is low. Therefore, we measure the collective incentive of other firms to bailout a distressed firm i as follows:

$$\text{Bailout Incentive} = \frac{\text{market value} \times \min_j(d_{ij})}{\text{operating profit}} \tag{4}$$

The market value of the firm reflects investors belief on its future profitability and survival probability. A distressed firm could afford a higher interest rate payment when the market value is higher relative to its current loss indicated by the operating profit. The larger this multiplier, the stronger the future profitability of the firm, enabling it to offer higher interest rates for new borrowed debt, attracting more firms to participate in the bailout.

[7] we will henceforth refer to it as "distribution"

By definition 3, the bailout cost rate is a decreasing function of a firm's closeness to the distressed firm. Therefore, if even the least connected firm of the distressed firm i is closely linked to the distressed firm so that the bailout cost is low, the least connected firm will be willing to participate in the bailout. In that case, all firms would have an incentive to participate. That's why we introduce the multipler $\min_j(d_{ij})$ in the bailout incentive indicator.

We expect that a higher level of our bailout incentive indicator leads to a larger feasible bailout set A and a higher probability of distressed firm survival, else being equal, which reduces loan default probability of the firm. Usually, not all firms will participate in the bailout of the distressed firm. For the robustness of our empirical results, we progressively raise the potential lower bound of A when constructing the bailout incentive indicator in section 5.3. More specifically, we shall replace $\min_j(d_{ij})$ in equation (4) by higher percentiles of d_{ij} there. For example, when we replace $\min_j(d_{ij})$ by the median of d_{ij}, the underlying implication is that if the bailout cost rate of the firm with median degree of closeness to the distressed firm i is low enough (d_{ij} high enough), the median firm and firms with even closer ties with firm i will have an incentive to bailout.

Bailout ability: Bailout ability indicator is calculated according to proposition 2. Similarly, due to the ambiguity of set A, we also use the minimum of d_{ij} to represent d_{ij}^{amin} in constructing the set **A** in our baseline models, and use firm's cash flow as a proxy variable for π_j and π_i. We set $\alpha_{ij} = \frac{1}{d_{ij}}$. The bailout ability indicator for firm i is[8]:

$$\text{Bailout Ability} = \sum_{j=1}^{n}(1 - \frac{1}{d_{ij}})cfo_j + cfo_i \tag{5}$$

where cfo_i is the operating cash flow of firm i .

Again, for robustness, we progressively raise the lower bound of A to construct the bailout ability indicator in section 5.3. Since less firms are included in the feasible bailout set, we expect a larger impact of the measure of bailout ability on firm survival. Intuitively, when there are ample firms in A, bailout fund is abundant, and a marginal increase in bailout fund has little impact on firm survival. Conversely, when there are limited number of firms in A, bailout fund is scarce, and a marginal increase in bailout fund has strong impact on firm survival.

Distribution: We introduce two measures of firms' distribution of closeness of industry connections. One is the mean of d_{ij} for each i, another is the skewness of d_{ij} for each i. We introduce these two indicators to test hypothesis 1 and 2. In order to emphasize the relative closeness of the interconnections among various industries in the economy and eliminate the impact of changes in the input-output distribution of the overall economy, we adjust the distribution characteristics as follows:

$$\begin{aligned} Mean_i &= \frac{Mean_i^{raw}}{\sum_{j=1}^{n} Mean_j^{raw}} \\ Skewness_i &= \frac{Skewness_i^{raw}}{\sum_{j=1}^{n} Skewness_j^{raw}} \end{aligned} \tag{6}$$

where $Mean_i^{raw}$ and $Skewness_i^{raw}$ represent the original mean and skewness of d_{ij} for each i, respectively.

Trade credit: We use the total accounts payable minus the total accounts receivable) to measure trade debt. We use this indicator to test hypothesis 3.

Other variables: In addition, we also use the company's financial data as control variables to eliminate the influence of other factors on the amount of bank loan defaults, including the scale of maturing debt[9] (Ddue), sales, total asset (lnasset), net cash assets (cash), ownership (type) and return on asset (ROA).

Descriptive statistics are shown in Table 1, including our main variables of interest and covariates. To visually compare the characteristics of input-output distributions across different industries, we include the descriptive statistics of both scaled and unscaled mean and skewness data. The skewness of all industries is positive and varies between 0.030 and 3.658, indicating that some industries have thicker right tails in the distribution of input-output relationships, and have closer connections with many other industries. The mean value of the distribution fluctuates between 0 and 0.011, indicating the presence of some industries whose distribution is closer to the right and generally more closely related to other industries. The characteristics of skewness and mean of the distribution are consistent with the description of the example in Figure 3.

5. Empirical Result

Based on the theoretical analysis, we build an econometric model as follow:

$$\text{Bank Loan Loss}_{it} = \alpha + KIV_{it}\beta + Control_{it}\gamma + f_i + v_t + \epsilon_{it} \tag{7}$$

where KIV is the key independent variables including $Bailout\ Incentive_{it}$, $Bailout\ Ability_{it}$, $Skewness_{it}$, $Mean_{it}$ and $Net\ Trade\ Debt_{it}$; $Control_{it}$ represents a vector of control variables; f_i and v_t represents individual fixed effects and time fixed effects, respectively; ϵ_{it} is the unobserved error term.

5.1. Baseline

The results of the baseline models are shown in Table 2. Models (1)-(4) focus on the four types of key variables: bailout incentive, bailout ability, distribution characteristics, and trade credit, each included separately as independent variables. Model (5) simultaneously considers the impact of bailout incentive and bailout ability on bank loan losses. Model (6) simultaneously takes into account the input-output distribution

[8]Since the actual bailou cost is unobservable, we employ a simplified cost formula as a proxy. Naturally, this does not equate to the real cost of the bailout. Therefore, negative values do not indicate the firm's weaker ability to receive bailout funds but rather serve as a relative concept, reflecting the strength or weakness of its capacity to obtain such a bailout.

[9]The logarithm of the sum of long-term debt and short-term debt due within one year lagged by one year

Table 2: The Impact of Bailout Incentive and Ability on Bank Loan Losses

Bank Loan Loss	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bailout Incentive	-1.579***				-1.555***		-1.592***
	(-3.357)				(-3.416)		(-3.728)
Bailout Ability		-8.649**			-9.629**		-8.159**
		(-2.457)			(-2.556)		(-2.198)
Skewness			-76.643**			-80.175***	-71.033**
			(-2.518)			(-2.611)	(-2.146)
Mean			-40.202**			-42.690**	-42.522**
			(-2.055)			(-2.162)	(-1.976)
Net Trade Debt				-12.642**		-13.478**	-14.643***
				(-2.136)		(-2.396)	(-2.642)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2703	3024	3024	3024	2703	3024	2703
adj. R^2	0.740	0.746	0.750	0.749	0.741	0.751	0.745

Standard errors are robust standard errors and cluster at the individual level. t statistics in parentheses. Each regression includes all control variables and control the firm-fixed effects and time-fixed effects. $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

and trade credit characteristics of firms. Model (7) incorporates all key variables. All key variables show expected signs. All specifications include control variables, firm and time fixed effects.

Bailout incentive is found to negatively and significantly affect bank loan losses, suggesting that firms capable of offering greater incentives to others are more likely to receive bailout fund, resulting in a decrease in the amount of overdue bank loans.

Bailout ability is also found to be a significant and negative determinant of bank loan losses, which implies that if the firms included in the maximum feasible bailout set have more abundant liquidity, the firm in distress is more likely to receive bailout fund, hence experiencing fewer instances of bank loan delinquencies.

Table 3: The Effect of Bailout Incentive and Ability under different distributions

Bank loan Loss	Grouped by Skewness		Grouped by Mean	
	(1)	(2)	(3)	(4)
	Low	High	Low	High
Bailout Incentive	-1.516***	-1.286	-3.782***	-1.685***
	(-3.517)	(-1.546)	(-3.100)	(-3.325)
Bailout Ability	-231.558*	-7.022*	-17.158	-8.942**
	(-1.791)	(-1.805)	(-0.408)	(-2.278)
Net Trade Debt	-13.268	-15.220**	-36.430***	-10.489*
	(-1.513)	(-2.032)	(-3.084)	(-1.760)
Control	Yes	Yes	Yes	Yes
N	1158	1535	762	1911
adj. R^2	0.743	0.758	0.745	0.767

Standard errors are robust standard errors and cluster at the individual level. t statistics in parentheses. Each regression includes all control variables and control the firm-fixed effects and time-fixed effects. $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

The mean and skewness of the firm's distribution of closeness to other industries are both significantly negative, supporting hypothesis 1.

An increase in trade debt level significantly reduces bank loan losses from the firms, which supports hypothesis 3.

5.2. *Group regression results*

In order to further investigate the influence of input-output distribution on bailout behavior, we divided the sample into two groups by skewness and mean of d_{ij}, and then conduct regression separately for each group using three other key variables: bailout incentive, bailout ability and net trade debt. The outcome is as summarized in Table 3. Notably, bailout incentive has a stronger impact on bank loan losses from firms with a lower-mean and more left-skewed input-output distribution, supporting our hypothesis 2.

5.3. *What happens if the feasible bailout set shrinks?*

As we have discussed in section 4.2, we use the sample minimal of d_{ij} to construct the indicator of collective bailout incentive for the distressed firm i. A large bailout incentive indicator suggests that the benefit of participating in the bailout action for firm i outweighs the cost for the firm with the minimal d_{ij}. Since all firms have a lower bailout cost than the minimal d_{ij} firm, a large enough bailout incentive indicator guarantees that all firms participate in the bailout. However, in practice not all firms participate in the bailout. To test the robustness of our baseline results, we progressively increase the percentile of d_{ij} used to construct the bailout incentive indicator. More specifically, we redefine the bailout incentive indicator as follows:

$$\text{Bailout Incentive} = \frac{\text{market value} \times d_{ij}^{perc(k)}}{\text{operating profit}}, \qquad (8)$$

Table 4: The Result of Different Feasible Set

Bank Loan Loss	(1)	(2)	(5)	(7)	(1)	(2)	(5)	(7)
	Panel A: 15th percentile				**Panel B: 20th percentile**			
Bailout Incentive	-0.315***		-0.315*	-0.319*	-0.247***		-0.247*	-0.249*
	(-4.173)		(-1.777)	(-1.811)	(-3.823)		(-1.723)	(-1.754)
Bailout Abilitye		-2.825**	-3.122***	-2.680**		-3.502**	-3.878***	-3.333**
		(-2.579)	(-2.783)	(-2.381)		(-2.581)	(-2.785)	(-2.386)
Skewness				-69.503***				-69.526***
				(-3.056)				(-3.057)
Mean				-42.304***				-42.230***
				(-3.940)				(-3.933)
Net Trade Debt				-14.676***				-14.687***
				(-4.809)				(-4.812)
	Panel C: 25th percentile				**Panel D: 50th percentile**			
Bailout Incentive	-0.217***		-0.216*	-0.218*	-0.108***		-0.107*	-0.110*
	(-4.206)		(-1.870)	(-1.899)	(-3.477)		(-1.836)	(-1.894)
Bailout Ability		-3.990**	-4.448***	-3.792**		-8.649**	-9.678***	-8.211**
		(-2.455)	(-2.618)	(-2.226)		(-2.457)	(-2.618)	(-2.216)
Skewness				-70.121***				-70.960***
				(-3.085)				(-3.126)
Mean				-42.465***				-42.478***
				(-3.955)				(-3.955)
Net Trade Debt				-14.668***				-14.650***
				(-4.806)				(-4.800)

Standard errors are robust standard errors and cluster at the individual level. t statistics in parentheses. Each regression includes all control variables and control the firm-fixed effects and time-fixed effects. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

where $\min_j(d_{ij})$ in equation 4 is replaced by $d_{ij}^{perc(k)}$, which is set to the 15th percentile, 20th percentile, 25th percentile and 50th percentile of the distribution of d_{ij} to generate four alternative indicators of bailout incentive.

Similarly, we use all firms' liquidity to construct the bailout ability indicator in our baseline regressions. Intuitively, if all firms' available cash flow increase, cash flow of the firms in the feasible bailout set might also increase. However, firms with limited industrial connections with the distressed firm might not participate in the bailout. Therefore, we progressively shrink the feasible bailout set to reconstruct the bailout ability indicator. More specifically, the alternative indicators are constructed as follows:

$$\mathbf{A} := \{j \neq i, 1 < j < n : d_{ij} > d_{ij}^{perc(k)}\},$$
$$\text{Bailout Ability} = \sum_{j \in A}(1 - \frac{1}{d_{ij}})cfo_j + cfo_i, \tag{9}$$

where $d_{ij}^{perc(k)}$ is the kth percentile of d_{ij} for each i. Again, we set k to 15, 20, 25, 50 progressively.

We re-estimate our model with the alternative bailout incentive and ability indicators. The results are shown in Table 4 and 5.

In Panels A-D of Tables 4 and 5, we use different percentiles as the lower bound of the maximum feasible set. Table 4 suggests that our baseline regression results hold no matter which lower bound is used. Both stronger bailout incentive and ability reduce bank loan losses. Consistent with our hypothesis 1, firms with higher-mean and right-skewed distribution of closeness to other firms generate less loan bosses to banks. Firms with a higher level of trade debt cause less losses to banks, supporting our hypothesis 3.

One notable pattern in the regression coefficients is that as the set of firms used to construct the bailout incentive and ability indicators shrinks, the absolute value of the marginal effect of the bailout incentive indicator decreases while the absolute value of the marginal effect of the bailout ability indicator increases. As we have discussed above, a large bailout incentive indicator suggests that for firms with a level of industrial connections no less than $d_{ij}^{perc(k)}$, the benefit of bailout might outweigh the cost. The smaller the percentile k, the more firms might be attracted to the set of lending firms by a large bailout incentive indicator. As for the bailout ability indicator, a larger value suggests a larger amount of usable funds for firms with a level of industrial connections no less than $d_{ij}^{perc(k)}$. However, when $d_{ij}^{perc(k)}$ is small, many firms, which have a level of industrial connections larger than $d_{ij}^{perc(k)}$, might not be willing to participate in the bailout even though they have funds available. As $d_{ij}^{perc(k)}$ increases, the set of firms with a level of industrial connections larger than $d_{ij}^{perc(k)}$ shrinks, and less firms outside the feasible

bailout set will be included in the calculation of the ability indicator, which should strengthens the marginal effect of bailout ability indicator.

Group regression results in table 5 further suggests that hypothesis 2 still holds. More specifically, bailout incentive has a stronger marginal effect on bailout outcome in the group of firms with lower-mean and more left-skewed distribution of closeness to other firms.

6. Conclusion

This study explores the specific impact mechanisms of firm input-output linkages and trade credit linkages on inter-firm bailout behaviors and bank loan losses through theoretical analysis and empirical testing. The results indicate that stronger incentive and ability of inter-firm lending when firms face financial distress significantly reduce bank loan losses. Firms of which the distribution of closeness to other industries has a higher mean and skewness are more likely to be bailed out during financial distress and hence, have a lower probability of bank loan default. Firms with a higher level of trade credit also have a lower probability of bank loan default. Those results have important policy implications for financial risk prevention, crisis resolution, and credit risk management.

Table 5: The Grouped Regression Result of Different Feasible Set

Bank loan Loss	Grouped by Skewness		Grouped by Mean	
	(1)	(2)	(3)	(4)
	Low	High	Low	High
Panel A: 15th percentile				
Bailout Incentive	-0.324***	-0.243	-1.054***	-0.324***
	(-4.296)	(-0.643)	(-3.110)	(-4.195)
Bailout Ability	-45.504*	-2.292*	-7.519	-2.848**
	(-1.692)	(-1.877)	(-0.597)	(-2.329)
Net Trade Debt	-13.346	-15.235**	-36.399***	-10.529*
	(-1.523)	(-2.035)	(-3.074)	(-1.763)
Panel A: 20th percentile				
Bailout Incentive	-0.255***	-0.225	-0.796***	-0.255***
	(-3.724)	(-0.687)	(-2.911)	(-3.724)
Bailout Ability	-59.596*	-2.879*	-9.112	-3.552**
	(-1.739)	(-1.898)	(-0.596)	(-2.337)
Net Trade Debt	-13.378	-15.242**	-36.393***	-10.540*
	(-1.526)	(-2.037)	(-3.076)	(-1.765)
Panel A: 25th percentile				
Bailout Incentive	-0.215***	-0.302	-0.705***	-0.219***
	(-4.358)	(-0.963)	(-3.135)	(-4.166)
Bailout Ability	-75.897*	-3.296*	-9.928	-4.104**
	(-1.763)	(-1.845)	(-0.514)	(-2.280)
Net Trade Debt	-13.376	-15.241**	-36.452***	-10.512*
	(-1.525)	(-2.036)	(-3.080)	(-1.760)
Panel A: 50th percentile				
Bailout Incentive	-0.115***	-0.077	-0.152***	-0.142***
	(-3.317)	(-1.231)	(-3.320)	(-4.421)
Bailout Ability	-231.626*	-7.023*	-17.268	-9.021**
	(-1.792)	(-1.806)	(-0.411)	(-2.288)
Net Trade Debt	-13.320	-15.217**	-36.418***	-10.511*
	(-1.515)	(-2.031)	(-3.081)	(-1.760)

Standard errors are robust standard errors and cluster at the individual level. t statistics in parentheses. Each regression includes all control variables and control the firm-fixed effects and time-fixed effects. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Firstly, the prevention of financial risks should not be limited to within the financial system. As the scale of debt connections between firms expands, their lending behaviors can also have significant impacts on financial risks. Industries or firms with a central position[10] in input-output relationships should receive more attention. On the one hand, they can serve as providers of liquidity for other firms, and the liquidity condition of central industries (firms) plays a crucial role in the resilience and risk resistance of the entire real economy and financial system. On the other hand, in the real economy, there is a problem similar to being "too big to fail." When central industries (firms) are impacted externally, they can access more bailout funds, making them more stable. However, this position may lead to excessive debt and higher moral hazard. Therefore, stricter regulation of central industries (firms) may be necessary.

Second, policy tools which support inter-firm lending during economic crises could help stabilize the financial system. During financial crises, due to decreased risk appetite among banks, there is often a significant contraction in credit volume, tightening financing constraints for businesses, reducing debt servicing capacity, increasing bank bad debts, further lowering risk appetite, and entering a debt contraction cycle. At this point, central banks injecting liquidity into commercial banks cannot directly improve their asset situations, making it difficult to increase their risk appetite. Implementing inter-firm lending support tools to promote the liquidity and supply of inter-firm lending can effectively alleviate the repayment pressure on bank loans, prevent the economy from entering a debt contraction. Moreover, the real economy, especially small and micro-firms, face increased difficulty in obtaining bank credit during crises, making their demand for inter-firm lending stronger (Carbó-Valverde et al., 2016). Increasing inter-firm lending can alleviate their liquidity constraints and enable them to recover faster from crises by relying more on inter-firm lending, which is beneficial for enhancing economic resilience and shortening recession cycles. As other bailout policies, the inter-firm lending support tools can also generate moral hazard. The optimal policy tradeoff is an interesting area of future research.

Finally, when banks conduct credit risk management, they should reassess the role of inter-firm lending. Using the firm's liquidity ratio as an indicator of its debt repayment ability may not reflect its actual ability to repay bank loans. In risk assessment, attention should be paid not only to the credit risk of the firm itself but also to its ability to obtain trade debt. This study demonstrates that actual loan losses for banks are not only related to the financial condition of the firm itself but also to its

[10] We define such industries or firms as those who have a right-skewness distribution of d_{ij} and a large $\sum_{j=1,j\neq i}^{n} d_{ij}$.

input-output position, trade credit position, and ability to obtain bailout funds. For firms with large loan amounts, stress tests can be conducted on their net trade debt to more accurately analyze the expected losses of bank loans, effectively reducing bank loan losses and increasing returns.

Appendix A. Proof of proposition 1

The present value of the interest received by firm j from the bailout objective firm i is

$$PV_{ij} = \pi_j^b \times \frac{r_i}{\bar{r}}$$

and the bailout cost for firm j to bailout distressed firm i is

$$\alpha_{ij}\pi_j^b,$$

where π_j^b is the cash flow used by firm j for the bailout Therefore, the incentive compatibility condition is met if the present value of the interest received by firm j is larger than the bailout cost:

$$\pi_j^b \times \frac{r_i}{\bar{r}} > \alpha_{ij}\pi_j^b$$

which reduces to the condition in proposition 1.

References

Acemoglu, D., Akcigit, U., Kerr, W., 2016. Networks and the macroeconomy: An empirical exploration. NBER Macroeconomics Annual 30, 273–335.

Acemoglu, D., Carvalho, V., Ozdaglar, A., Tahbaz-Salehi, A., 2012. The network origins of aggregate fluctuations. Econometrica 80, 1977–2016.

Acemoglu, D., Ozdaglar, A., Tahbaz-Salehi, A., 2015. Systemic risk and stability in financial networks. American Economic Review 105, 564–608.

Afrouzi, H., Bhattarai, S., 2023. Inflation and GDP Dynamics in Production Networks: A Sufficient Statistics Approach. NBER Working Papers 31218. National Bureau of Economic Research, Inc.

Allen, F., Qian, Y., Tu, G., Yu, F., 2019. Entrusted loans: A close look at china's shadow banking system. Journal of Financial Economics 133, 18–41.

Altinoglu, L., 2021. The origins of aggregate fluctuations in a credit network economy. Journal of Monetary Economics 117, 316–334.

Bernard, B., Capponi, A., Stiglitz, J., 2022. Bail-ins and bailouts: Incentives, connectivity, and systemic stability. Journal of Political Economy 130, 1805 – 1859.

Biais, B., Gollier, C., 1997. Trade credit and credit rationing. The Review of Financial Studies 10, 903–37.

Bigio, S., La'O, J., 2020. Distortions in production networks*. The Quarterly Journal of Economics 135, 2187–2253.

Boissay, F., Gropp, R., 2013. Payment defaults and interfirm liquidity provision*. Review of Finance 17, 1853–1894.

Carbó-valverde, S., Rodríguez-fernández, F., Udell, G.F., 2016. Trade credit, the financial crisis, and sme access to finance. Journal of Money, Credit and Banking 48, 113–143.

Cook, L., 1999. Trade credit and bank finance: Financing small firms in russia. Journal of Business Venturing 14, 493–518.

Cuñat, V., 2007. Trade credit: suppliers as debt collectors and insurance providers. The Review of Financial Studies 20, 491–527.

De Graeve, F., Schneider, J.D., 2023. Identifying sectoral shocks and their role in business cycles. Journal of Monetary Economics 140, 124–141.

Demirguc-Kunt, A., Maksimovic, V., 2001. Firms as financial intermediaries - evidence from trade credit data. Policy Research Working Paper Series 2696. The World Bank.

Duffie, D., Saita, L., Wang, K., 2007. Multi-period corporate default prediction with stochastic covariates. Journal of Financial Economics 83, 635–665.

Fabbri, D., Klapper, L., 2016. Bargaining power and trade credit. Journal of Corporate Finance 41, 66–80.

Franks, J., Sussman, O., 2005. Financial distress and bank restructuring of small to medium size uk companies. Review of Finance 9, 65–96.

Garcia-Appendini, E., Montoriol-Garriga, J., 2013. Firms as liquidity providers: Evidence from the 2007-2008 financial crisis. Journal of Financial Economics , 109.

Jacobson, T., Schedvin, E., 2015. Trade credit and the propagation of corporate failure: An empirical analysis. Econometrica 83, 1315–1371.

Kiyotaki, N., Moore, J., 1997. Credit cycles. Journal of Political Economy 105, 211–48.

Kiyotaki, N., Moore, J., 2001. Credit Chains. Edinburgh School of Economics Discussion Paper Series. Edinburgh School of Economics, University of Edinburgh.

Klapper, L., Laeven, L., Rajan, R., 2012. Trade credit contracts. The Review of Financial Studies 25, 838–867.

Leitner, Y., 2005. Financial networks: Contagion, commitment, and private sector bailouts. Journal of Finance 60, 2925–2953.

Luo, S., 2020. Propagation of financial shocks in an input-output economy with trade and financial linkages of firms. Review of Economic Dynamics 36, 246–269.

Marotta, G., 1997. Does trade credit redistribution thwart monetary policy? evidence from italy. Applied Economics 29, 1619–1629.

McMillan, J., Woodruff, C., 1999. Interfirm relationships and informal credit in vietnam. The Quarterly Journal of Economics 114, 1285–1320.

Meltzer, A.H., 1960. Mercantile credit, monetary policy, and size of firms. The Review of Economics and Statistics 42, 429–437.

Nilsen, J.H., 2002. Trade credit and the bank lending channel. Journal of Money, Credit and Banking 34, 226–253.

Ono, M., 2001. Determinants of trade credit in the japanese manufacturing sector. Journal of the Japanese and International Economies 15, 160–177.

Raddatz, C., 2010. Credit chains and sectoral comovement: Does the use of trade credit amplify sectoral shocks? The Review of Economics and Statistics 92, 985–1003.

Ramey, V., 1992. The source of fluctuations in money: Evidence from trade credit. Journal of Monetary Economics 30, 171–193.

Reischer, M., 2024. Finance-thy-Neighbor. Trade Credit Origins of Aggregate Fluctuations. Working Papers. Georgetown University.

Rogers, L.C.G., Veraart, L.A.M., 2013. Failure and rescue in an interbank network. Management Science 59, 882–898.

Smith, J., 1987. Trade credit and informational asymmetry. Journal of Finance 42, 863–72.

Uchida, H., Udell, G., Watanabe, W., 2013. Are trade creditors relationship lenders? Japan and the World Economy 25-26, 24–38.

Uesugi, I., Yamashiro, G.M., 2004. How Trade Credit Differs from Loans: Evidence from Japanese Trading Companies. Discussion papers. Research Institute of Economy, Trade and Industry (RIETI).

Wilner, B.S., 2000. The exploitation of relationships in financial distress: The case of trade credit. Journal of Finance 55, 153–178.

Zhang, H., Xia, M., Su, R., Lin, C., 2021. The compilation of the time series input-output tables in china: 1981—2018. Statistical Research 38, 3–23.