

Supply Chain Concentration and the Cost of Bank Loans

Abstract

This study examines how the concentration of major customers and suppliers influences a firm's bank loan costs. Using a comprehensive sample of listed companies in Taiwan from 2008 to 2019, we document a significant inverted U-shaped relationship between supply chain concentration and the cost of debt. Initially, higher concentration leads to increased financing costs, a result that is significantly more pronounced for firms with higher default probabilities or those whose major customers face lower switching costs. However, as the strategic interdependence between a firm and its major partners deepens, the cost of bank loans begins to decline, suggesting that strong supply chain ties eventually yield certification and monitoring benefits that alleviate information asymmetry. These findings remain robust across alternative measures of concentration, propensity score matching (PSM), and instrumental variable (IV) analysis.

Keywords: Supply chain, concentration, Debt Cost, Inverted U-shaped, Endogeneity.

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1. Introduction

The impact of major customer-supplier relationships on a firm's financing costs remains a subject of intense debate in the academic literature¹. While concentrated supply chain linkages can contribute to profitability through strategic coordination, they may also impose significant costs and operational risks that ultimately affect the borrower's credit profile. This paper explores how the dynamic nature of these relationships influences bank loan costs, proposing that the effect is non-linear rather than strictly positive or negative.

From a risk-based perspective, supply chain concentration is often viewed as a "profit barrier" or a source of financial vulnerability for upstream firms. Major customers frequently leverage their superior bargaining power to demand concessions, such as price reductions (Krolikowski and Yuan, 2017), extensive pre-sales support (Kelly and Gosman, 2000), or delayed payments (Murfin and Njoroge, 2015). Furthermore, major customers may seek to transfer operational risks to suppliers (Kolay et al., 2016) or demand more conservative financial reporting to mitigate their own informational disadvantages (Hui et al., 2012). To stabilize these relationships, firms often undertake relationship-specific investments (RSI)—such as specialized R&D or unique manufacturing assets—which typically retain little to no value outside the specific partnership (Allen and Phillips, 2000; Banerjee et al., 2008; Kale and Shahrur, 2007). Such dependencies expose firms to significant "hold-up" risks and operational uncertainty. Consequently, lenders often perceive high concentration as an increased default risk, demanding higher interest spreads to compensate for these vulnerabilities (Nikolov et al., 2021; Ni et al., 2023).

¹ In this paper, the terms "supplier" and "customer" refer to companies that act as suppliers or customers in a given company's supply chain. Major customers refer to the company's downstream firms, and major suppliers refer to the company's upstream firms. Companies are borrowers who get a loan from a bank.

A similar logic applies to supplier concentration. When a firm relies heavily on a few key suppliers, it faces reduced bargaining power and may be forced into unfavorable terms, such as making advance payments that deplete internal liquidity (Zhang et al., 2020). Moreover, the risk of supply interruptions creates operational dependencies that are reflected in the lending market (Kesavayuth and Zikos, 2012). Therefore, banks may view high supplier concentration as a risk factor, imposing stricter loan conditions (Kalwani and Narayandas, 1995) and higher financing costs (Zhang et al., 2020; Hasan et al., 2020).

Conversely, an efficiency-based perspective suggests that concentrated supply chains offer strategic advantages. Close relationships can reduce costs through economies of scale (Patatoukas, 2012), improved asset utilization (Kaplan and Narayanan, 2001), and superior inventory management (Casalin et al., 2017). Over time, operational efficiencies and the "implicit certification effect"—where a sustained partnership with a major customer signals borrower quality to lenders—can overcome the threats posed by bargaining imbalances (Campello and Gao, 2017; Irvine et al., 2016). Mature relationships foster higher trust, mutual commitment, and information sharing (Bauer et al., 2018), alleviating information asymmetry (Cen et al., 2016) and potentially leading to more favorable financing terms (Ferrando and Mulier, 2015; Cen et al., 2016).

To reconcile these conflicting perspectives, we propose that the impact of supply chain concentration on bank loan costs follows a non-linear, inverted U-shaped trajectory. Drawing on the relational life-cycle hypothesis (Dwyer et al., 1987; Irvine et al., 2016), we argue that the costs associated with bargaining pressure and specific investments dominate in the early stages of a relationship, elevating credit risk (Campello and Gao, 2017; Hasan et al., 2020). Relationship-specific investments are most substantial and necessary during this phase to create future value (Wilson, 1995). However, as the relationship develops and reaches a critical threshold of maturity, the benefits of operational efficiency (Patatoukas, 2012; Jap and

Anderson, 2007) and supply chain certification (Cen et al., 2016; Hasan et al., 2020) begin to outweigh these initial costs, resulting in a reduction of borrowing rates.

Utilizing Taiwan's regulatory environment, which mandates listed firms to disclose major customers and suppliers accounting for over 10% of annual revenue or purchases² (Cai and Zhu, 2020; Dhaliwal et al., 2016), we test our hypotheses using a comprehensive sample from 2008 to 2019. Our empirical results confirm a significant inverted U-shaped relationship. Furthermore, we find that this relationship is more pronounced when firms have a higher probability of default (Altman, 1968) or when customer switching costs are lower (Lee et al., 2020; Hui et al., 2012).

Our study offers two primary contributions. First, we provide the first systematic evidence that bank loan costs vary non-linearly over the supply chain relationship life cycle. While prior studies have explored the U-shaped impact of customer concentration on firm profitability (Irvine et al., 2016; Kwak and Kim, 2020), we extend this logic to the debt market. Second, we provide a holistic view by simultaneously examining both customer and supplier concentration. By demonstrating that both follow a similar non-linear trajectory, we contribute a more nuanced understanding of how supply chain dynamics shape financing conditions, complementing existing research on both customer concentration (Ni et al., 2023; Nikolov et al., 2021) and supplier concentration (Zhang et al., 2020; Hasan et al., 2020; Rahaman et al., 2020).

The rest of the paper is organized as follows. In Section 2, we review related literature and develop testable hypotheses. In Section 3, we describe the data and the research design. We present our empirical results in Section 4 and conclude in Section 5.

² This provision in Taiwan for identifying major customers (suppliers) has been exploited elsewhere in the literature (Cai and Zhu, 2020; Dhaliwal et al., 2016). Where the company is prohibited by contract from revealing the name of a client or where a trading counterpart is an individual who is not a related party, it may use a code in place of the actual name.

2. Literature review and hypothesis development

2.1 The impact of supply chain concentration on bank loan costs

Existing literature offers conflicting predictions regarding how customer or supplier concentration influences a firm's financing constraints and costs. From a risk-based perspective, firms relying on a small number of major customers face heightened financial vulnerability, as a substantial portion of their sales is contingent on these specific partners. Given that major customers typically do not provide explicit certifications or guarantees for future purchases, excessive reliance can lead to severe revenue erosion if the relationship terminates, thereby weakening the firm's financial stability (Itzkowitz, 2013).

Furthermore, while major customers contribute significantly to revenue, they often leverage their bargaining power to become "high-cost" customers, compromising the firm's profitability (Kaplan and Narayanan, 2001; Kwak and Kim, 2020). This bargaining pressure manifests through demands for price reductions (Krolikowski and Yuan, 2017), extensive pre-sales support (Kelly and Gosman, 2000), or irregular purchasing patterns (Itzkowitz, 2013). Major customers may further erode margins by delaying payments or switching to competitors with more favorable contracts (Dhaliwal et al., 2016; Irvine et al., 2016). Additionally, to satisfy their need for timely identification of unfavorable news, major customers may leverage their bargaining power to obtain conservative financial information from suppliers (Hui et al., 2012). To manage these potential risks, firms may become more conservative in decision-making or even abandon risky but profitable projects (Cao et al., 2021). Ultimately, upstream suppliers often bear the operational risks inherent to these large customers (Kolay et al., 2016).

Regarding asset specificity, firms are frequently required to undertake relationship-specific investments (RSI) or R&D as a demonstration of long-term commitment (Wang, 2012; Itzkowitz, 2013). To establish strategic alliances, these costly investments generate significant

financial risks (Titman, 1984). Such investments involve specialized manufacturing procedures (Bolton and Scharfstein, 1998) which retain little to no value outside the specific relationship (Allen and Phillips, 2000; Banerjee et al., 2008; Kale and Shahrur, 2007). This lack of alternative utility creates a "hold-up problem," exposing the firm to financial risk (Titman, 1984; Shleifer and Vishny, 1992). Such RSI projects are challenging to abandon even when short-term losses are incurred (Irvine et al., 2016). For instance, in the automobile industry, parts suppliers often become "trapped" by specific manufacturers due to the specificity of assets, hindering their ability to bargain on equal footing (David et al., 2024). Ultimately, major customer concentration adversely affects financing constraints through these bargaining effects (Nikolov et al., 2021). Given that long-term relationships expose firms to high costs and risks, they face significant operational pressure (Campello and Gao, 2017; Hasan et al., 2020).

Regarding supplier concentration, high concentration reduces a firm's bargaining power, allowing suppliers to demand advance payments and thus depleting internal funds (Zhang et al., 2020). Additionally, adverse business shocks to a major supplier can jeopardize the downstream firm's operations (Kesavayuth and Zikos, 2012). In some contexts, such as Chinese firms, supplier concentration has been found to make financial constraints more severe and increase firm cash holdings (Zhang et al., 2020). Consequently, banks may impose stricter loan conditions and higher financing costs (Kalwani and Narayandas, 1995; Hasan et al., 2020). Notable hold-up risks and supply shocks increase the firm's solvency constraints (Jorion and Zhang, 2009; Zhang et al., 2020).

Conversely, an efficiency-based perspective suggests that concentrated supply chains offer strategic benefits. Close relationships enable operational efficiencies through economies of scale (Patatoukas, 2012). Reduced product diversity helps lower inventory costs (Casalin et al., 2017), while collaborative marketing efforts enhance expenditure feasibility (Kalwani and Narayandas, 1995). In international evidence, companies can improve the financial

performance of patenting activities by concentrating their customer base, as observed in Japanese manufacturers (Kunieda and Takashima, 2024). As relationships mature, resulting efficiencies can overcome the threat of bargaining power imbalances (Irvine et al., 2016). Optimizing inventory control through supply chain architecture can ultimately reduce total borrowing costs (Rahaman et al., 2020). Based on these perspectives, we propose:

H1. Major customer-supplier concentration significantly impacts the cost of bank loans.

2.2 Non-linear dynamics: a relationship life cycle perspective

The relationship between a firm and its customers or suppliers is not static but evolves through distinct phases. In the early stages, firms prioritize stabilization by accepting requests for relationship-specific investments or R&D. While these investments increase customer switching costs (Krolikowski and Yuan, 2017)³, major customers possess dominant bargaining power, characterized by demands for lower prices or delayed payments (Murfin and Njoroge, 2015), which reduces profitability and increases operational risk. Maintaining such relationships initially exposes the firm to high costs and risks (Campello and Gao, 2017; Hasan et al., 2020). Consequently, banks lending to firms with high concentration at this stage likely demand higher interest rates to compensate for these risks. Notably, relationship-specific investments are most substantial and necessary in the early stages, as they form the foundation for maximum value creation during later maturity (Wilson, 1995).

As supply chain relationships develop and mature, the firm's cost-benefit structure shifts. Throughout the process of building long-term ties, relationship-specific assets—which hold no value outside the partnership—are deployed. Over time, firms benefit from improved processes and relationship-specific economies of scale, ultimately lowering costs (Kalwani and Narayandas, 1995). Operational efficiency improvements can be viewed as rewards for initial RSI that accrue as the relationship matures (Leuthesser & Kohli, 1995). This maturity stage

³ Please also refer to Banker, Byzalov, and Plehn-Dujowich (2014); Kang, Mahoney, and Tan (2009)

can persist for a considerable period, reflecting the long-term benefits of specific investments (Jap and Anderson, 2007) and increasing value creation from major partnerships (Eggert et al., 2006).

This evolutionary process aligns with the life cycle hypothesis (Dwyer et al., 1987). From this perspective, the development and changes in supply chain relationships at different stages exert varying impacts on operational risks and profits. Strong customer relationships drive firms to invest more in R&D and innovation to meet customer needs (Krolikowski and Yuan, 2017). While these ties create a "lock-in effect" that limits a firm's ability to switch partners (Rahaman et al., 2020), a highly concentrated customer base also incentivizes both parties to pursue interdependence and cooperation. Such cooperation creates production efficiencies, and customers seeking sustainable growth are willing to support value-creation processes, thereby enhancing the competitive advantages of both parties in the product market. Customers engaged in long-term transactions may even adapt their production techniques to handle inputs from the firm, with the value of these investments depending on the firm's future prospects (Crawford et al., 2020).

Recent studies suggest that long-term relationships generate an implicit certification effect, conveying signals about borrower quality (Cen et al., 2016; Hasan et al., 2020)⁴. Major customers, who possess superior knowledge of product quality and financial health through business interactions, typically screen firms before entering contracts (Cen et al., 2016). These long-term business ties foster higher trust, mutual commitment, and information sharing (Bauer et al., 2018). Furthermore, major customers possess specific informational advantages over other stakeholders: they have superior knowledge of product quality and can assess financial

⁴ Cen et al. (2016) propose that major customers have certain information advantages over other stakeholders. For example, major customers know the quality of their company's products better than any other stakeholder. Second, major customers can assess a company's financial health through its willingness to accept delayed payments or extend trade credit. Finally, customers can update information more timely than other stakeholders through their business interactions with the company. These risks are less visible to other stakeholders.

health through the firm's willingness to extend trade credit or accept delayed payments. Maintaining such relationships yields valuable information about the buyer's own customers, optimizes inventory management, and reduces administrative expenses, thereby expanding profitability (Reinartz and Kumar, 2000; Kalwani and Narayandas, 1995).

Finally, heavy investments in technology and human capital to meet major customers' specifications act as a barrier to entry for competitors. Additionally, investments in partnerships and specific assets increase a firm's ability to pass on price increases to customers. Consequently, firms encounter lower risk in longer-term relationships and gain indirect financing advantages from implicit future commitments. Observing the stability of these supply chain relationships and expecting future growth, banks are willing to provide more favorable loan interest rates.

In summary, we anticipate that customer-supplier relationships undergo a dynamic evolution. In the early stages of establishment, firms incur high relationship-specific investments or grant concessions due to bargaining imbalances, leading to sub-optimal profitability and high operational risk, which results in higher bank loan rates. Conversely, as the relationship matures and products gain certification, leading to an increased sales share, banks expect improved financial performance and offer more favorable rates. Based on these arguments, we propose:

H2. Major customer-supplier concentration has an inverted U-shaped relationship with the cost of bank loans.

3. Research design

3.1 Data and sample selection

This study uses a sample of Taiwan's listed companies from 2008 to 2019 to study the impact of the company's major customer-supplier relationships on bank loan costs. We used

several modules of the Taiwan Economic Journal (TEJ) database to test our hypotheses. First, we require these listed firms to have NTD borrowing data from the banks in the sample. The information includes stock code, company name, lending banks, lending amount, interest rate, fixed or float interest rate, and start and end date. Second, we exclude financial firms and firms with missing information on any of our key variables.

Then, we matched information on firms' supply chains from firms' annual reports to define major customer and supplier concentration. Similar to other countries, the Taiwan Financial Supervisory Commission requires listed firms to disclose important information to protect investors. According to Article 18 of the "Regulations Governing Information to be Published in Annual Reports of Public Companies," firms should disclose the customers' names, percentages, and amounts of total purchases (sales) whose sales proportions are larger than 10% in any of the last two years and explain the reasons for their increases or decreases. Finally, this study has 12,466 firm-year observations drawn from 1,480 unique firms.

3.2 Variable construction

In this section, we outline the definitions of variables used in this study.

Cost of bank loan: We measure the cost of bank loans using the loan amount-weighted interest rate proposed by Hsu et al. (2017) to control the impact of the loan amount. The Financial Supervisory Commission stipulates that publicly traded companies should disclose debt information in Article 10 of the "Regulations Governing the Preparation of Financial Reports by Securities Issuers." First, we obtain loan details from TEJ's database, which contains statistics on the financing cost of company loans, including floating and fixed interest rates. The highest and lowest interest rates are averaged if a company's loans include floating interest rates. Next, we multiply the average loan interest rate by the loan amount to calculate the interest for each loan. We then divide each company's total borrowing interest by the company's total borrowing amount to obtain the bank loan cost of each company (*WgtInt*).

Customer/supplier concentration: The Taiwan Financial Supervisory Commission requires listed firms to disclose information about major customers/suppliers that account for over 10% of their annual sales (purchases). We create three measures to capture the extent to which a firm's customer/supplier base is concentrated. First, we define an indicator variable ($DMajCus / DMajSup$) that is set to one if a firm discloses at least one customer (supplier) whose sales (purchases) to total sales (purchases) account for at least 10% of total sales (purchases), and zero otherwise. Second, we follow a method from existing research (Dhaliwal et al., 2016; Patatoukas, 2012) and apply the Herfindahl-Hirschman Index to capture customer/supplier concentration ($CusHHI / SupHHI$). This approach incorporates two elements of customer (supplier) base dispersion, namely the number of major customers (suppliers) j with which the company i interacts and the relative importance of each major customer (supplier) j to the company i 's annual sales (purchases) in year t . This variable ranges from zero to one. The larger this variable, the higher the concentration of major customers (suppliers). A value of one indicates that the company only relies on a single major customer (supplier). Thus, the specific formulae we use for a customer ($CusHHI$) and supplier ($SupHHI$) are as follows:

$$CusHHI_{it} = \sum_{j=1}^J \left(\frac{Sales_{ijt}}{Sales_{it}} \right)^2 \dots\dots\dots (1)$$

$$SupHHI_{it} = \sum_{j=1}^J \left(\frac{Purchases_{ijt}}{Purchases_{it}} \right)^2 \dots\dots\dots (2)$$

The third measure of customer (supplier) concentration, denoted by $SumMajCus/SumMajSup$, is defined as the fraction of a firm i 's annual sales (purchases) that are accounted for by all major customers (suppliers) j in year t as shown below. The higher (lower) value of $SumMajCus/SumMajSup$ represents more (less) customer/supplier concentration.

$$SumMajCus_{it} = \sum_{j=1}^J \left(\frac{Sales_{ijt}}{Sales_{it}} \right) \dots\dots\dots (3)$$

$$SumMajSup_{it} = \sum_{j=1}^J \left(\frac{Purchases_{ijt}}{Purchases_{it}} \right) \dots\dots\dots (4)$$

We include control variables that affect the cost of bank loans. Firm size (*LnTA*), calculated by the natural log of total assets, is used to control for the negative effect of firm size. Compared with small companies, large companies tend to have more collateral and higher information transparency, thus reducing financing constraints (Almeida et al., 2004). In addition, financial leverage (*DebtRatio*), calculated by total assets minus stockholders' equity, divided by the total assets, is likely to increase default risk, and a positive association between leverage and loan cost is expected. High profitability (*ROA*) is likely to reduce the operating risk, and a negative association between ROA and loan cost is expected. *Tobins' Q* stands for the market-based measure of firm value and is another negative factor affecting bank loan cost. Moreover, we employ Altman's (1968) *Z-score* to measure a firm's likelihood of default. We predict there is a negative relationship between the *Z-score* and the cost of a bank loan because a higher Z-score has a lower probability of default. Furthermore, a firm's insider ownership (*BoardOw*), calculated by the shareholding ratio of directors and supervisors, is likely to increase profitability (Kwak and Kim, 2020) and have a negative association between *BoardOw* and loan cost. Detailed variable definitions appear in Appendix A.

Table 1 summarizes the statistics for the cost of bank loans, major customer (supplier) concentration, and control variables. It shows that the mean of loan cost (*WgtInt*) is 0.018, with a standard deviation equal to 0.007. Compared with 70.8% of companies with at least one major customer whose sales ratio is at least higher than 10%, the proportion of firms with at least one major supplier whose purchasing ratio is at least higher than 10% is even higher, 78.9%. This means that a very high proportion of Taiwanese companies have at least one major supplier, which means they have the advantage of reducing costs when considering bargaining power. However, the proportion of companies with major customers is also high. Operational risks are also high when major customers threaten the company with bargaining power or investment

requirements. The average firm in our sample has a log value of 15.347 for total assets, a log value of 13.0396 for fixed assets, and a debt ratio of 0.403. Moreover, the average *ROA* and *Tobins' Q* are 0.029 and 1.146, respectively. Furthermore, the company's insider ownership averages 0.225 and a standard deviation of 0.145.

[Insert Table 1 Here]

Table 2 reports the number and percentage of firm-year observations, as well as customer concentration (*SumMajCus*, *DMajCus*, *CusHHI*) and supplier concentration (*SumMajSup*, *DmajSup*, *SupHHI*) for each year in Panel A and each industry group in Panel B. As shown in Panel A, the number of firm-year observations per year increased yearly from 955 in 2008 to 1,170 in 2019. We can see that the concentration of major customers and major suppliers is consistently declining. Although the concentration of companies with major customers and suppliers has declined, it is still high compared to other countries.⁵

Panel B of Table 2 demonstrates that our sample is from a wide variety of industry groups. Firms in the electronics industry are the largest contributors to our sample (51.3%). Each remaining industry group represents approximately 0.39% to 6.49% of the sample. Judging from having at least one major customer (*DMajCus*), companies in the auto and electronics industries have a higher proportion of major customers. Judging from having at least one major supplier (*DMajSup*), oil firms and electrical cable companies have a higher proportion of major suppliers. From the perspective of customer concentration (*CusHHI*), the food and auto industries have the highest proportion of sales to major customers. From the standpoint of supplier concentration (*SupHHI*), the oil and iron industries have the highest proportion of sales to major customers. It also shows that concentration measures vary across sectors. Therefore, our main regression should control for industry-fixed effects.

⁵ In Dhaliwal et al. (2016), there are 0.26 of U.S. firms has major customer and average customer HHI is only 0.09 during 1981 to 2011. In Kunieda and Takashima (2024), Japan firms have an average customer HHI of 0.062 during 1991 to 2017.

[Insert Table 2 Here]

3.3 Empirical Models

To test our hypotheses, we estimate the following panel regression model in Eq. (5) for major customers and Eq. (6) for major suppliers.

$$WgtInt_{it} = \beta_0 + \beta_1 MCC_{it-1} + \sum \beta Control_{it-1} + \sum Industry_i + \sum Year_t + \varepsilon_{it} \dots \dots \dots (5)$$

$$WgtInt_{it} = \beta_0 + \beta_1 MSC_{it-1} + \sum \beta Control_{it-1} + \sum Industry_i + \sum Year_t + \varepsilon_{it} \dots \dots \dots (6)$$

The dependent variable (*WgtInt*) is measured in year *t*, while all independent variables are measured in year *t-1*. *MCC* is the major customer concentration of firm *i* in year *t-1* (*DMajCus*, *CusHHI*, *SumMajCus*), and *MSC* is the major supplier concentration of firm *i* in year *t-1* (*DMajSup*, *SupHHI*, *SumMajSup*). We control for borrower fundamentals, including the logarithm of total assets (*LnTA*), financial leverage (*DebtRatio*), return on assets (*ROA*), *Tobins' Q*, default probability (*Z-score*), and insider ownership (*BoardOw*). In all models, we also account for industry effects to address the fact that some industries are more susceptible to major customer-supplier concentration risk than others and year effects to address the possible impact of economic fluctuations during the sample period.

In hypothesis 2, we predict that major customer-supplier concentration has an inverted U-shaped relationship with the cost of bank loans. To test this hypothesis, we employ the procedure of a prior study (Kwak and Kim, 2020), which tested for a U-shaped relationship between customer concentration and firm profitability. For this analysis, we include the linear and squared terms of concentration (*MCC* and *MCC*²) in the following Eq. (7) for customers and Eq. (8) for suppliers.

$$\begin{aligned}
WgtInt_{it} = & \beta_0 + \beta_1 MCC_{it-1} + \beta_2 MCC_{it-1}^2 + \sum \beta Control_{it-1} + \sum Industry_i + \\
& \sum Year_t + \varepsilon_{it} \quad \dots
\end{aligned}
\tag{7}$$

$$\begin{aligned}
WgtInt_{it} = & \beta_0 + \beta_1 MCC_{it-1} + \beta_2 MSC_{it-1}^2 + \sum \beta Control_{it-1} + \sum Industry_i + \\
& \sum Year_t + \varepsilon_{it} \quad \dots
\end{aligned}
\tag{8}$$

We predict that if the coefficient of *MCC* (β_1) is significantly positive and the coefficient of *MCC*² (β_2) is significantly negative, then the association between customer-supplier concentration and cost of bank loans is an inverted U-shaped relationship.

4. Empirical results

4.1 Univariate test

Table 3 presents the results of the univariate tests, comparing the loan costs between firms with and without major supply chain partners. For the full sample, both the mean (0.0183) and median (0.0170) loan costs for firms with major customers are higher than those for firms without (0.0170 and 0.0158, respectively), with a mean difference of 0.0013 significant at the 1% level. A similar pattern emerges for supplier concentration, where the mean loan cost for firms with major suppliers (0.0183) is significantly higher than for non-major firms (0.0169), yielding a mean difference of 0.0015 ($t=9.94$) significant at the 1% level. These results remain consistent and significant across the electronics and non-electronics industries. These preliminary findings align with the risk-based view, suggesting that lenders initially perceive supply chain concentration as an operational risk.

[Insert Table 3 Here]

4.2 Multivariate regression results

To further examine the relationship between supply chain concentration and bank loan costs, we estimate the multivariate models specified in Equations (5) and (6). To ensure the reliability of our results, all continuous variables are winsorized at the 1st and 99th percentiles, and t-statistics are calculated using robust standard errors. Multicollinearity is not a concern, as Variance Inflation Factors (VIF) remain below 3.3 for all variables.

4.2.1 Testing Hypothesis 1: The Linear Relationship

Table 4 reports the testing results for Hypothesis 1. In Panel A, the estimated coefficient of *SumMajCus* in Column (1) is 0.0007 ($t=4.04$), and the coefficients for *CusHHI* (0.0009, $t=3.31$) and *DMajCus* (0.0005, $t=4.57$) are also significantly positive at the 1% level. These findings confirm a positive relationship between major customer concentration and the cost of bank loans, aligning with prior studies indicating that high concentration elevates perceived operational risk (Campello and Gao, 2017; Dhaliwal et al., 2016). Similarly, Panel B shows that all three measures of supplier concentration (*SumMajSup*, *SupHHI*, *DMajSup*) are significantly positive at the 1% level. These results are consistent with past literature suggesting that supplier concentration increases operational risks and financial constraints (Zhang et al., 2020; Hasan et al., 2020). The empirical results support hypothesis 1.

Beyond supply chain variables, most control variables are significant and align with theoretical expectations. The coefficient for firm size (*LnTA*) is significantly negative (-0.0010, $t=-19.27$), indicating that larger firms benefit from lower loan costs due to greater collateral and information transparency (Almeida et al., 2004). We also observe that higher profitability (*ROA* and *Tobins' Q*) is negatively correlated with loan costs, reflecting lower operating risk. Financial leverage (*DebtRatio*) is positively associated with financing costs (0.0074, $t=19.64$) as it increases default risk. Following Altman (1968), the *Z-score* is significantly and negatively related to financing costs (-0.0015, $t=-17.37$), confirming that safer firms face lower borrowing

costs. Finally, insider ownership (*BoardOw*) is significantly negative (-0.0028 , $t=-7.30$), supporting the view that insider equity aligns interests and improves profitability (Kwak and Kim, 2020), thus lowering financing costs.

4.2.2 Testing Hypothesis 2: The Inverted U-shaped Relationship

To test for a non-linear relationship, we include linear and quadratic terms of concentration in our regression to the regression equation to test whether the company's bank loan costs and concentration are inverted U-shaped. As shown in Column (4) of Table 4 Panel A, the coefficient of *SumMajCus* remains significantly positive (0.0024 , $t=4.59$), while the squared term *SumMajCus*² is significantly negative (-0.0019 , $t=-3.42$).

This finding indicates that the concentration of a company's major customers is associated with heightened operational risks during the early stages of establishing customer relationships, resulting in higher loan interest rates for the firm. These operational risks likely stem from the outsized bargaining power of major customers or the heavy requirements for relationship-specific investments (RSI). As discussed in existing literature, such as Campello and Gao (2017) and Hasan et al. (2020), these early-stage dependencies elevate the lender's perception of risk. However, after the company establishes stable, long-term relationships with major customers, it secures continuous or larger-scale orders. This maturation allows the company to improve its operating efficiency due to economies of scale, eventually leading to a reduction in borrowing costs.

In Table 4 Panel B, Column (4), the regression results for the linear (*SumMajSup*) and quadratic (*SumMajSup*²) terms of supplier concentration are similar to the results obtained for major customers. By observing these stable relationships within the supply chain, banks believe that major customers or suppliers are willing to cooperate closely with the firm, which effectively provides the firm with "supply chain certification". This certification signals borrower quality and mitigates information asymmetry between the firm and the lender. Banks

are, therefore, willing to provide more favorable loan interest rates once supply chain concentration reaches a certain level.

[Insert Table 4 Here]

To confirm the statistical significance of these inverted U-shaped relationships, we followed the three-step procedure proposed by Lind and Mehlum (2010)⁶:

Step 1: We confirmed the significance of the quadratic terms ($SumMajCus^2$ and $SumMajSup^2$) in our main models, as shown in Table 5.

Step 2: The slopes at both extremes of the data range were shown to be sufficiently steep. For customer concentration, the slope at the lowest point (X_l) is positive (0.0024, $p < 0.01$), while the slope at the highest point (X_h) is significantly negative (-0.0154, $p < 0.01$).

Step 3: Using the Fieller (1954) method, we identified an inflection point of 0.623 for customer concentration, which falls within the data limits and the 90% confidence interval (0.537 to 0.820). The Appropriate U test is -3.265 with a p-value of 0.001.

Consistent results were also obtained for supplier concentration. Collectively, these findings provide robust empirical support for Hypothesis 2, confirming that major customer and supplier concentration exhibit an inverted U-shaped relationship with bank loan costs.

[Insert Table 5 Here]

4.3 The effect of default probability

The presence of major customers or suppliers presents a dual impact on a firm: while it can enhance profitability through improved operating efficiency, it also introduces significant operational risks. For instance, a concentrated customer base exposes the firm to substantial cash flow losses if major clients switch to competitors or encounter financial distress (Dhaliwal et al., 2016). Similarly, the loss of a major supplier can disrupt operations,

⁶ For detailed proofs and discussions, please refer to Lind and Mehlum's (2010).

as finding a replacement for large-scale inputs is often challenging (Kesavayuth and Zikos, 2012). While financially sound firms may weather these risks, those with a high probability of default face greater scrutiny from lenders, who are likely to demand higher interest rates to compensate for these supply chain vulnerabilities.

However, intense reliance on major partners can also foster deeper customer-supplier relationships, which in turn improve a firm's financial performance (Irvine et al., 2016; Kwak and Kim, 2020). Such interdependence encourages cooperation and production efficiency, leading to more relationship-specific investments and innovation (Krolkowski and Yuan, 2017). Furthermore, continuous and long-term key customer relationships can act as a signal of a company's quality and enhance borrower goodwill, ultimately leading to lower loan pricing through a certification effect (Cen et al., 2016).

To test these predictions, we utilize Altman's (1968) *Z-score* to evaluate the firm's financial health. The lower the *Z-score*, the greater the likelihood of the company's financial failure; the higher the *Z-score*, the safer the company is financially. We define an indicator variable, *HighBankruptcy* (*HBP*), set to one if the firm's *Z-score* is below the sample median in a given year, and zero otherwise. We then interact this indicator with our concentration measures.

The results in Table 6 reveal a critical distinction based on the firm's financial stability. For firms with robust financial health (*HBP*=0), we find no significant relationship between major customer or supplier concentration and loan costs. Specifically, in Column (4) of Panel A, the coefficient of the base quadratic term (*SumMajCus*²) is near zero (-0.00002) and statistically insignificant (*t*=-0.02\$), indicating that concentration does not exert a non-linear influence on borrowing costs for these stable firms.

However, the inverted U-shaped relationship is highly pronounced for firms with a higher probability of corporate default (*HBP*=1). In this high-risk group, the linear interaction

term ($SumMajCus \times HBP$) is significantly positive at 0.0046 ($t=4.64$), while the quadratic interaction term ($SumMajCus^2 \times HBP$) is significantly negative at -0.0040 ($t=-3.69$). Similar results are observed for suppliers in Panel B, where the quadratic interaction ($SumMajSup^2 \times HBP$) is significantly negative at -0.0024 ($t=-2.29$).

These findings confirm that the strategic trade-off between operational risk and supply chain certification is primarily a concern for financially distressed borrowers. While high concentration initially exacerbates the financing constraints of risky firms, the eventual "certification" provided by close, mature supply chain ties effectively improves the borrower's goodwill and proves their quality to lenders. Consequently, this close association allows even firms with a high probability of default to eventually obtain more favorable interest rates from banks.

[Insert Table 6 Here]

4.4 The effect of customer switching costs

Beyond financial distress, another significant risk associated with a concentrated customer base is the potential for defection. If major customers switch to alternative suppliers, the firm may suffer substantial financial losses. We therefore consider whether the inverted U-shaped relationship between concentration and loan costs is more pronounced when barriers to switching are lower. According to existing research, when a firm's market share is low, customers have access to more alternative suppliers, which reduces their switching costs and increases the likelihood of defection (Lee et al., 2020; Hui et al., 2012). This heightens the borrower's business and cash flow risk from the lender's perspective.

To test this mechanism, we construct an interaction variable using major customer concentration and a low switching cost indicator. Specifically, *Low Switching Cost (LSC)* is defined as an indicator variable equal to one if a firm's market share in an industry in a given year is lower than the median market share of all firms in the same industry in the sample

(excluding the firm itself), and zero otherwise. This variable effectively captures scenarios where major customers possess higher mobility due to lower switching costs ($LSC=1$).

The empirical results in Table 7 demonstrate that the impact of concentration on financing costs is strictly conditional on the level of switching costs. For firms whose major customers face switching costs above the median ($LSC=0$), we find that none of the customer concentration measures are statistically related to bank loan costs. As shown in Column (1), the coefficient of the base linear term $SumMajCus$ is -0.0001 ($t = -0.35$), and in Column (4), the base quadratic term $SumMajCus^2$ is similarly insignificant at -0.0009 ($t = -1.31$). This evidence suggests that when customers are effectively 'locked-in' to the relationship due to high switching barriers, lenders do not perceive a concentrated customer base as a primary source of default risk, as the likelihood of sudden revenue loss is significantly mitigated.

In contrast, the inverted U-shaped relationship is exclusively significant for firms facing low switching costs ($LSC=1$). For this group, the linear interaction term $SumMajCus \times LSC$ is significantly positive at 0.0015 ($t = 4.68$), while the quadratic interaction term $SumMajCus^2 \times LSC$ is significantly negative at -0.0029 ($t = -2.62$). These findings indicate that while a concentrated customer base initially increases financing costs when defection risk is high, this risk is eventually mitigated as the relationship matures into a strategic partnership.

Consistent with the certification and goodwill perspective, these results suggest that strong ties to the supply chain can demonstrate a borrower's quality even in competitive environments. This close relationship allows companies to obtain loans at lower interest rates once a critical threshold of concentration is reached, even when their individual market power is limited. Overall, the evidence in Table 7 confirms that the strategic trade-off between operational risk and supply chain certification is primarily driven by firms whose customers have the flexibility to switch to alternative input providers.

[Insert Table 7 Here]

4.5 Propensity score matched sample analysis

A primary econometric concern in this study is that supply chain concentration may not be randomly assigned. Specifically, the decision to maintain a concentrated customer or supplier base may be correlated with unobserved firm characteristics that also influence bank loan costs, such as profitability (Campello and Gao, 2017) or underlying operational risks (Kesavayuth and Zikos, 2012). This potential endogeneity, characterized by omitted variable bias, could lead to spurious correlations if not properly addressed. Furthermore, if control variables exhibit non-linear effects that are not sufficiently differentiated, the main results may be biased. To mitigate these selection biases and ensure a more robust comparison, we employ a Propensity Score Matching (PSM) approach, consistent with procedures utilized in prior supply chain literature (e.g., Dhaliwal et al., 2016).

We conduct a PSM procedure to estimate the causal effects of concentration on bank loan costs. For the treatment group, we identify firms that report at least one major customer (or supplier); for the control group, we seek matching firms without any major partners in the same year. First, we estimate the likelihood of a firm having a major partner using a logit model, where the indicator variable *DMajCus* (or *DMajSup*) is regressed on all control variables from Equation (7), alongside year and industry fixed effects. Second, using the predicted propensity scores, we match each treatment firm one-to-one with a control firm that has the closest score within a strict 0.1% caliper width, without replacement. This process yields a PSM subsample of 6,838 firm-year observations (comprising 3,419 matched pairs) for the customer concentration analysis and 4,994 firm-year observations for the supplier concentration analysis.

Using these matched subsamples, we re-estimate our OLS regressions. The multivariate results reported in Table 8 remain highly consistent with our primary findings in Table 4. For customer concentration in Panel A, the estimated coefficient of the linear term in Column (4) is 0.0018 ($t = 2.42$), while the quadratic term ($SumMajCus^2$) is significantly negative at -0.0010

($t = -2.80$). Equally important, the results for supplier concentration in Panel B confirm the robustness of our findings. In Column (4), the linear term for supplier concentration is significantly positive at 0.0029 ($t = 3.59$), while the quadratic term ($SumMajSup^2$) is significantly negative at -0.0025 ($t = -2.71$).

These consistent results across both panels reinforce the conclusion that the inverted U-shaped relationship is a robust economic phenomenon rather than an artifact of selection bias or firm-specific omitted variables. Even after matching firms on various fundamental characteristics, banks continue to price loans based on the strategic trade-off between initial operational risk and eventual supply chain certification as the relationship matures. In summary, the PSM analysis confirms that our main empirical evidence is robust to the potential endogeneity of supply chain structures.

[Insert Table 8 Here]

4.6 Instrumental variable analysis

To address potential endogeneity arising from self-selection or omitted variable bias—where unobserved factors might simultaneously influence a firm’s supply chain concentration and its cost of debt—we employ a Two-Stage Least Squares (2SLS) approach. Following Cai and Zhu (2020), we utilize the lagged industry average of customer (supplier) concentration as our instrumental variable (IV). Specifically, for each firm-year, the IV is calculated as the average customer (supplier) concentration of all other firms within the same industry (excluding the focal firm) to ensure the instrument captures industry-wide shifts rather than firm-specific idiosyncratic shocks.⁷

This instrument is theoretically sound for two reasons. First, firms within the same industry often share similar supply chain structures and market environments, ensuring a

⁷ In addition to using one lag year as the IV to conduct empirical experiments, we also used the lag of two or three years as the IV to conduct empirical experiments, consistent conclusions are drawn. Other studies use industry averages of pivotal variables as instrumental variables such as Dhaliwal et al. (2016), see footnote 36.

strong correlation with firm-level concentration. Second, while industry-level trends influence a firm's strategic choices, the historical (lagged) industry average is unlikely to directly affect a specific firm's current bank loan pricing except through its impact on the firm's own concentration levels, thus satisfying the exclusion restriction.

Table 9 demonstrates the results of the 2SLS regression. In the first stage (reported in Panels A and C), we regress each firm's concentration measure on the lagged industry average IV and the same set of control variables as defined in Table 4. The dependent variables across our four specifications capture different dimensions of supply chain structure: Model (1) uses the indicator variable *DMajCus* (*DMajSup*) to measure the existence of major partners; Model (2) employs *HHICus* (*HHISup*) to capture concentration intensity; and Model (3) uses *SumMajCus* (*SumMajSup*) to represent the total percentage of sales or purchases. Finally, Model (4) incorporates the predicted values and their squares to test the inverted U-shaped relationship between concentration and bank loan costs. The first-stage results show that the coefficients on the IV are positive and statistically significant at the 1% level across all specifications. This confirms the relevance condition, indicating that industry-level trends are strong predictors of firm-level concentration.

Panels B and D report the second-stage results, where the bank loan cost (*WgtInt*) is regressed on the fitted values from the first stage. Controlling for company characteristics, we find that the predicted values of the concentration measures in Models (1) to (3) remain positively and significantly related to financing costs. Most importantly, the results of Model (4) confirm that the relationship between major customer (supplier) concentration and bank financing costs follows an inverted U-shape. This consistency with our baseline findings suggests that while initial concentration increases loan costs due to risk concerns, the costs eventually decrease as relationships deepen beyond a certain threshold. In sum, our empirical conclusions are robust to endogeneity concerns.

[Insert Table 9 Here]

5. Conclusion

This study investigates the impact of supply chain concentration on bank loan costs, contributing to the growing body of literature that examines how firm-to-firm relationships influence credit market outcomes. Utilizing a comprehensive sample of listed companies in Taiwan from 2008 to 2019, we provide robust empirical evidence of a significant inverted U-shaped relationship between a firm's customer (supplier) concentration and its cost of debt.

Our findings reveal a dual-effect mechanism. Initially, as concentration increases, the company's loan costs rise. This reflects the risk-enhancing effect documented in previous literature: high reliance on a few major partners heightens operational risks, which may stem from the superior bargaining power of those partners or the necessity for the firm to make relationship-specific investments. Such vulnerabilities, including the potential for sudden supply disruptions, lead banks to perceive higher credit risk, thereby imposing stricter financing constraints and higher interest rates.

However, our research highlights a critical turning point. As supply chain relationships deepen and concentration reaches a certain threshold, the certification and monitoring effects begin to dominate. Long-term, high-stakes cooperation incentivizes major customers and suppliers to more rigorously screen and monitor the focal firm. Because these partners possess unique, private information, their continued relationship serves as a positive signal to lenders, effectively alleviating information asymmetry. Consequently, banks are willing to offer more favorable interest rates to firms with deeply integrated supply chains.

Furthermore, the intensity of this relationship is contingent upon the firm's specific environment. Our analysis demonstrates that the impact of concentration on financing costs is significantly more pronounced when a company faces a higher probability of default or when

switching costs for major customers are lower. These results suggest that banks are particularly sensitive to supply chain stability when the focal firm's standalone financial health is fragile.

Finally, to ensure the validity of our conclusions, we employed three distinct measurement methods for supply chain concentration and addressed potential endogeneity concerns through Propensity Score Matching (PSM) and Instrumental Variable (IV) analysis. The consistency of our findings across these methodologies reinforces the robustness of the inverted U-shaped hypothesis. In conclusion, our study provides a more nuanced understanding of how supply chain structures shape corporate financing, offering valuable insights for both firm managers and financial institutions in their credit assessment processes.

References

- Allen, J., Phillips, G., 2000. Corporate equity ownership, strategic alliances, and product market relationships. *The Journal of Finance* 55, 2791–2815.
- Almeida, H., Campello, M., Weisbach, M. S., 2004. The cash flow sensitivity of cash. *The Journal of Finance* 59, 1777–1804.
- Altman, E. I., 1968. Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The Journal of Finance* 23, 589–609.
- Banerjee, S., Dasgupta, S., Kim, Y., 2008. Buyer-supplier relationships and the stakeholder theory of capital structure. *The Journal of Finance* 63, 2507–2552.
- Banker, R., Byzalov, D., Plehn-Dujowich, J., 2014. Demand uncertainty and cost behavior. *The Accounting Review* 89 (3): 839–865.
- Bauer, A. M., Henderson, D., Lynch, D. P., 2018. Supplier internal control quality and the duration of customer-supplier relationships. *The Accounting Review* 93 (3): 59–82.
- Bolton, P., Scharfstein, D., 1998. Corporate finance, the theory of the firm, and organizations. *Journal of Economic Perspectives* 12, 95–114.
- Cai, K., Zhu, H., 2020. Customer-Supplier relationships and the cost of debt. *Journal of Banking and Finance* 110, 105686, 1-19.
- Campello, M., Gao, J., 2017. Customer concentration and loan contract terms. *Journal of Financial Economics* 123, 108–136.
- Cao, Y., Dong, Y., Ma, D., Sun, L., 2021. Customer concentration and corporate risk taking. *Journal of Financial Stability* 54, 10089.

- Casalin, F., Pang, G., Maioli, S., Cao, T., 2017. Inventories and the concentration of suppliers and customers: evidence from the Chinese manufacturing sector. *International Journal of Production Economics* 193, 148–159.
- Cen, L., Dasgupta, S., Elkamhi, R., Pungaliya, R., 2016. Reputation and loan contract terms: the role of principal customers. *Review of Finance* 20 (2), 501–533.
- Crawford, S., Huang, Y., Li, N., Yang, Z., 2020. Customer concentration and public disclosure: Evidence from management earnings and sales forecasts, *Contemporary Accounting Research* 37 (1), 131–159.
- David, T., Troege, M., Nguyen, H. M., Nguyen, H.T., 2024. Relationship-specific investments for up- and downstream firms and credit constraints. *Journal of Corporate Finance* 84, 102534, 1–22.
- Dhaliwal, D., Judd, J. S., Serfling, M., Shaikh, S., 2016. Customer concentration risk and the cost of equity capital. *Journal of Account and Economics* 61 (1), 23–48.
- Dwyer, F., Schurr, P., Oh, S., 1987. Developing buyer-seller relationships. *Journal of Marketing* 51 (2): 11–27.
- Eggert, A., Ulaga, W., Schultz, F., 2006. Value creation in the relationship life cycle: A quasi-longitudinal analysis. *Industrial Marketing Management* 35 (1): 20–27.
- Ferrando, A., Mulier, K., 2015. Firms' financing constraints: Do perceptions match the actual situation? *The Economic and Social Review* 46 (1), 87–117.
- Fieller, E. C., 1954. Some problems in interval estimation, *Journal of the Royal Statistical Society, Ser B* 16, 176–186.
- Hasan, I., Minnick, K., Raman, K., 2020. Credit allocation when borrowers are economically linked: an empirical analysis of bank loans to corporate customers. *Journal of Corporate Finance* 62, 101605.
- Hsu, E., Tsai, Y., Jhuang, R., 2017. Firm's external relationships and bank loan pricing: Empirical tests for bargaining power, information transfers and social network perspectives, and their linkages. *Journal of Management & Systems* 24(2), 135–165.
- Hui, K. W., Klasa, S., Yeung, P. E., 2012. Corporate suppliers and customers and accounting conservatism. *Journal of Accounting and Economics* 53, 115–135.
- Irvine, P. J., Park, S. S., Yildizhan, C., 2016. Customer-base concentration, profitability, and the relationship life cycle. *The Accounting Review* 91 (3), 883–906.
- Itzkowitz, J., 2013. Customers and cash: how relationships affect suppliers' cash holdings. *Journal of Corporate Finance* 19, 159–180.
- Jap, S., Anderson, E., 2007. Testing a life-cycle theory of cooperative interorganizational relationships: Movement across stages and performance. *Management Science* 53 (2): 260–275.
- Jorion, P., Zhang, G., 2009. Credit contagion from counterparty risk. *Journal of Finance* 64(5), 2053–2087.

- Kale, J., Shahrur, H., 2007. Corporate capital structure and the characteristics of suppliers and customers. *Journal of Financial Economics* 83, 321–365.
- Kalwani, M.U., Narayandas, N., 1995. Long-term manufacturer-supplier relationships: Do they pay off for supplier firms? *Journal of Marketing* 59, 1–16.
- Kang, M., Mahoney, J. T, Tan, D., 2009. Why firms make unilateral investments specific to other firms: The case of OEM suppliers. *Strategic Management Journal* 30(2), 117–135.
- Kaplan, R. S., Narayanan, V. G., 2001. Measuring and managing customer profitability. *Journal of Cost Management* 15(5), 5–15.
- Kelly, T., Gosman, M. L., 2000. Increased buyer concentration and its effects on profitability in the manufacturing sector. *Review of Industrial Organization* 17(1), 41–59.
- Kesavayuth, D., Zikos, V., 2012. Upstream and downstream horizontal R&D networks. *Economic Modelling* 29 (3), 742–750.
- Kolay, M., Lemmon, M., Tashjian, E., 2016. Spreading the misery? Sources of bankruptcy spillover in the supply chain. *Journal of Financial and Quantitative Analysis* 51 (6), 1955–1990.
- Krolkowski, M., Yuan, X., 2017. Friend or foe: customer-supplier relationships and innovation. *Journal of Business Research* 78, 53–68.
- Kunieda, Y., Takashima, K., 2024. The effect of customer-base concentration on the relationship between patents and financial performance. *Journal of Strategy and Management* 17(1), 101–122.
- Kwak, K., Kim, N., 2020. Concentrate or disperse? The relationship between major customer concentration and supplier profitability and the moderating role of insider ownership, *Journal of Business Research* 109, 648–658.
- Lee, S.M., Jiraporn, P., Song, H., 2020. Customer concentration and stock price crash risk. *Journal of Business Research* 110, 327–346.
- Leuthesser, L., Kohli, A. K., 1995. Relational behavior in business markets: Implications for relationship management. *Journal of Business Research* 34(3), 221–233.
- Lind, J. T., Mehlum, H., 2010. With or Without U? The Appropriate Test for a U-Shaped Relationship. *Oxford Bulletin Of Economics And Statistics* 72(1), 109–118.
- Murfin, J., Njoroge, K., 2015. The implicit costs of trade credit borrowing by large firms. *Review of Financial Studies* 28, 112–145.
- Ni, J., Cao, X., Zhou, W., Li, J., 2023. Customer concentration and financing constraints. *Journal of Corporate Finance* 82, 102432.
- Nikolov, B., Schmid, L., Steri, R., 2021. The sources of financing constraints. *Journal of Financial Economics* 139 (2), 478–501.
- Patatoukas, P. N., 2012. Customer-base concentration: implications for firm performance and capital markets. *The Accounting Review* 87 (2), 363–392.

- Rahamana, M. M., Rau, M. R., Zaman, A. A., 2020. The effect of supply chain power on bank financing. *Journal of Banking & Finance* 114, 105801.
- Reinartz, W. J., Kumar, V., 2000. On the profitability of long-life customers in a noncontractual setting: An empirical investigation and implications for marketing. *Journal of Marketing* 64 (4): 17–35.
- Shleifer, A., Vishny, R., 1992. Liquidation values and debt capacity: a market equilibrium approach. *Journal of Finance* 47, 1343–1366.
- Titman, S., 1984. The effect of capital structure on a firm's liquidation decision. *Journal of Financial Economics* 13, 137–151.
- Wang, J., 2012. Do firms' relationships with principal customers/suppliers affect shareholders' income? *Journal of Corporate Finance* 18, 860–878.
- Wilson, D. T. 1995. An integrated model of buyer-seller relationships. *Journal of the Academy of Marketing Science* 23 (4): 335–345.
- Zhang, X., Zou, M., Liu, W., Zhang, Y., 2020. Does a firm's supplier concentration affect its cash holding? *Economic Modelling* 90, P.527–535.

Table 1 Summary statistics

This table presents the summary statistics for customer and supplier concentration measures along with control variables. *WgtInt* is the cost of bank loan calculated by weighting the loan amount of the interest rate on bank loans. *SumMajCus* (*SumMajSup*) is the fraction of a firm's total sales to all customers (suppliers) that account for at least 10% of total sales (purchases). *CusHHI* is the customer sales-based Herfindahl-Hirschman Index. *DmajCus* is an indicator variable that is set to one if at least one customer whose sales to total sales account for at least 10% of total sales. *SupHHI* and *DmajSup* are concentration of major suppliers. Appendix A defines all variables. Continuous variables are winsorized at their 1st and 99th percentiles.

Variable	N	Mean	Std	P25	P50	P75
<i>Panel A. Cost of Bank Loan</i>						
WgtInt (Weighted interest rate)	12,466	0.018	0.007	0.012	0.016	0.021
<i>Panel B. Major Customer / Supplier Concentration</i>						
SumMajCus	12,466	0.330	0.315	0.000	0.262	0.547
CusHHI	12,466	0.125	0.207	0.000	0.044	0.139
DMajCus	12,466	0.708	0.455	0.000	1.000	1.000
NumMajCus	12,466	1.366	1.188	0.000	1.000	2.000
SumMajSup	12,466	0.417	0.336	0.117	0.375	0.695
SupHHI	12,466	0.186	0.257	0.014	0.077	0.243
DMajSup	12,466	0.789	0.408	1.000	1.000	1.000
NumMajSup	12,466	1.503	1.132	1.000	1.000	2.000
<i>Panel C. Control Variables</i>						
LnTA	12,466	15.347	1.373	14.400	15.180	16.130
TobinsQ	12,466	1.146	0.679	0.740	0.960	1.320
ROA	12,466	0.029	0.090	0.002	0.038	0.077
LnFixAsset	12,466	13.039	2.073	12.061	13.175	14.268
DebtRatio	12,466	0.403	0.166	0.283	0.389	0.508
BoardOw	12,466	0.225	0.145	0.120	0.188	0.294
Zscore	12,466	1.104	0.996	0.620	1.113	1.652
SwitchingCosts	12,466	0.022	0.069	0.001	0.004	0.015

Table 2 Sample distribution

This table reports the number and percentage of firm-year observations, as well as customer concentration (*SumMajCus*, *DMajCus*, *CusHHI*) and supplier concentration (*SumMajSup*, *DMajSup*, *SupHHI*) for each year in Panel A and each industry group in Panel B. The sample consists of 12,466 firm-year observations from 1,800 unique firms between 2008 and 2019.

Panel A: Distribution by year								
Year	N	Ratio%	Customer			Supplier		
			SumMajCus	DMajCus	CusHHI	SumMajSup	DMajSup	SupHHI
2008	955	7.66	0.412	0.766	0.178	0.553	0.874	0.276
2009	935	7.50	0.384	0.779	0.151	0.536	0.879	0.267
2010	962	7.72	0.389	0.771	0.153	0.541	0.887	0.268
2011	1,001	8.03	0.390	0.780	0.153	0.552	0.888	0.271
2012	1,031	8.27	0.346	0.727	0.139	0.425	0.820	0.190
2013	1,005	8.06	0.309	0.678	0.117	0.378	0.772	0.162
2014	1,025	8.22	0.305	0.676	0.119	0.369	0.756	0.154
2015	1,038	8.33	0.296	0.679	0.107	0.351	0.738	0.146
2016	1,073	8.61	0.314	0.682	0.118	0.361	0.739	0.150
2017	1,117	8.96	0.285	0.668	0.096	0.335	0.719	0.134
2018	1,154	9.26	0.282	0.658	0.096	0.335	0.723	0.128
2019	1,170	9.39	0.285	0.667	0.097	0.334	0.721	0.130
	12,466	100.0						
		0						
Panel B: Distribution by industry								
	N	Ratio%	Customer			Supplier		
			SumMajCus	DMajCus	CusHHI	SumMajSup	DMajSup	SupHHI
Electronics industry	6,395	51.30	0.368	0.809	0.127	0.423	0.819	0.183
Other	809	6.49	0.369	0.721	0.152	0.367	0.748	0.153
Building materials	788	6.32	0.317	0.529	0.156	0.499	0.787	0.257
Electrical machinery	667	5.35	0.358	0.736	0.150	0.276	0.688	0.116
Biomedical	531	4.26	0.305	0.633	0.121	0.383	0.766	0.164
Textile industry	493	3.95	0.256	0.657	0.091	0.487	0.868	0.185
Iron industry	474	3.80	0.196	0.513	0.061	0.622	0.930	0.301
Chemical industry	403	3.23	0.206	0.524	0.092	0.430	0.864	0.180
Trade dep. store	244	1.96	0.230	0.398	0.095	0.315	0.594	0.126
Food industry	243	1.95	0.295	0.527	0.191	0.340	0.638	0.180
Plastic industry	238	1.91	0.232	0.483	0.107	0.514	0.866	0.255
Shipping	238	1.91	0.272	0.534	0.086	0.173	0.475	0.070
Auto industry	184	1.48	0.480	0.967	0.173	0.353	0.707	0.206
Go sightseeing	184	1.48	0.157	0.299	0.072	0.234	0.386	0.109
Electrical cable	163	1.31	0.291	0.699	0.148	0.531	0.920	0.211
Rubber industry	118	0.95	0.293	0.636	0.133	0.384	0.746	0.142
Oil, electricity and gas	88	0.71	0.255	0.500	0.079	0.762	0.989	0.586
Paper Industry	84	0.67	0.225	0.440	0.126	0.359	0.512	0.222
Cement industry	73	0.59	0.245	0.712	0.157	0.541	0.877	0.223
Glass-ceramics	49	0.39	0.209	0.531	0.056	0.191	0.694	0.065
		100.0						
	12,466	0						

Table 3 Univariate test

This table shows the differences of loan cost between major customer (supplier) and non-major customer (supplier). The mean difference test provides the t value, and the median difference test uses the Wilcoxon Z-test. *** denote statistical significance at the 1%.

Variable: <i>WghInt</i>		Major (A)		Non-Major (B)		Test of difference (A-B)		
Sample	Type	Mean	Median	Mean	Median	Dif.	t-test	Wilcoxon Z-test
All industry	Customer	0.0183	0.0170	0.0170	0.0158	0.0013	(9.44) ***	(9.32) ***
	Supplier	0.0183	0.0169	0.0169	0.0156	0.0015	(9.94) ***	(10.01) ***
Electronics	Customer	0.0180	0.0168	0.0168	0.0150	0.0018	(8.10) ***	(8.96) ***
	Supplier	0.0187	0.0173	0.0173	0.0162	0.0013	(7.16) ***	(6.16) ***
Non-Electronics	Customer	0.0180	0.0167	0.0167	0.0153	0.0018	(8.04) ***	(7.93) ***
	Supplier	0.0185	0.0171	0.0171	0.0158	0.0014	(6.63) ***	(6.71) ***

Table 4 Multivariate regression results: concentration and cost of bank loan

This table reports results from OLS regressions relating the cost of bank loan to customer and supplier concentration measures and control variables for Taiwan firms from 2008 to 2019. The dependent variable (*WgtInt*) is the cost of bank loan calculated by weighting the loan amount of the interest rate on bank loans. *SumMajCus* (*SumMajSup*) is the fraction of a firm's total sales to all customers (suppliers) that account for at least 10% of total sales (purchases). *CusHHI* is the customer sales-based Herfindahl-Hirschman Index. *DmajCus* is an indicator variable that is set to one if at least one customer whose sales to total sales account for at least 10% of total sales. *SupHHI* and *DmajSup* are concentration of major suppliers. Control variables include LnTA, TobinsQ, ROA, LnFixAsset, DebtRatio, and BoardOW. Control variables are defined in Appendix A. All specifications include interacted year and industry fixed effects. Continuous variables are winsorized at their 1st and 99th percentiles. Standard errors are corrected for heteroskedasticity and clustering at the supplier level (t-statistics are in parentheses). *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Major customer concentration and cost of bank debt				
Variable	(1)	(2)	(3)	(4)
<i>SumMajCus</i>	0.0007 *** (4.04)			0.0024 *** (4.59)
<i>SumMajCus</i> ²				-0.0019 *** (-3.42)
<i>CusHHI</i>		0.0009 *** (3.31)		
<i>DMajCus</i>			0.0005 *** (4.57)	
LnTA	-0.0010 *** (-19.27)	-0.0010 *** (-19.43)	-0.0010 *** (-19.03)	-0.0010 *** (-18.87)
Tobins'Q	-0.0003 *** (-3.05)	-0.0003 *** (-2.97)	-0.0003 *** (-3.00)	-0.0003 *** (-3.05)
ROA	-0.0019 * (-1.85)	-0.0020 ** (-1.98)	-0.0019 * (-1.91)	-0.0018 * (-1.78)
LnFixAsset	0.0000 (-0.85)	0.0000 (-0.88)	0.0000 (-1.01)	0.0000 (-0.97)
DebtRatio	0.0074 *** (19.64)	0.0074 *** (19.63)	0.0074 *** (19.65)	0.0074 *** (19.64)
Zscore	-0.0015 *** (-17.37)	-0.0015 *** (-17.33)	-0.0015 *** (-17.29)	-0.0015 *** (-17.40)
BoardOW	-0.0028 *** (-7.30)	-0.0028 *** (-7.30)	-0.0028 *** (-7.32)	-0.0028 *** (-7.29)
Constant	0.0447 *** (53.57)	0.0449 *** (53.80)	0.0445 *** (52.67)	0.0444 *** (52.94)
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
Observations	12,424	12,424	12,424	12,423
Adjusted R ²	0.425	0.425	0.426	0.426
Panel B: Major supplier concentration and cost of bank debt				
Variable	(1)	(2)	(3)	(4)
<i>SumMajSup</i>	0.0005 *** (2.97)			0.0029 *** (5.56)
<i>SumMajSup</i> ²				-0.0025 *** (-4.83)

<i>SupHHI</i>		0.0006 *** (3.07)		
DMajSup			0.0006 *** (4.96)	
LnTA	-0.0010 *** (-19.29)	-0.0010 *** (-19.44)	-0.0010 *** (-19.28)	-0.0010 *** (-19.25)
TobinsQ	-0.0003 *** (-3.06)	-0.0003 *** (-2.88)	-0.0003 *** (-3.06)	-0.0003 *** (-3.06)
ROA	-0.0019 * (-1.84)	-0.0021 ** (-2.08)	-0.0019 * (-1.86)	-0.0018 * (-1.76)
LnFixAsset	0.0000 (-0.78)	0.0000 (-1.04)	0.0000 (-0.83)	0.0000 (-0.92)
DebtRatio	0.0074 *** (19.60)	0.0074 *** (19.63)	0.0074 *** (19.62)	0.0073 *** (19.58)
Zscore	-0.0015 *** (-17.40)	-0.0015 *** (-17.15)	-0.0015 *** (-17.42)	-0.0015 *** (-17.39)
BoardOW	-0.0028 *** (-7.39)	-0.0028 *** (-7.27)	-0.0029 *** (-7.46)	-0.0029 *** (-7.49)
Constant	0.0447 *** (52.46)	0.0452 *** (54.00)	0.0444 *** (52.14)	0.0444 *** (52.13)
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
Observations	12,424	12,424	12,424	12,423
Adjusted R ²	0.425	0.425	0.426	0.426

Table 5 Appropriate U test

This table shows test statistics from the appropriate U test and the derived Fieller interval. This method follows Lind and Mehlum (2010). Robust standard errors in parentheses and P-value in square bracket. *** denote significances at the 1% levels.

		<u>Customer .</u> <i>SumMajCus</i>	<u>Supplier .</u> <i>SumMajSup</i>
Concentration (X_l)	$\widehat{\beta}_1 =$	0.0024 *** (0.001)	0.0029 *** (0.001)
Concentration ² (X_l^2)	$\widehat{\beta}_2 =$	-0.0019 *** (0.001)	-0.0025 *** (0.001)
Slope at X_l	$\widehat{\beta}_1 + 2\widehat{\beta}_2 X_l =$	0.0024 *** (0.001)	0.0029 *** 0.001
Slope at X_h	$\widehat{\beta}_1 + 2\widehat{\beta}_2 X_h =$	-0.0154 *** (0.005)	-0.0251 *** 0.005
Appropriate U test		3.265 [0.001]	4.733 [0.000]
Extremum point	$-\widehat{\beta}_1/(2\widehat{\beta}_2) =$	0.623	0.567
90% confidence interval, Fieller method		[0.537, 0.820]	[0.512, 0.648]

Table 6 Effect of default probability

This table reports results from OLS regressions relating the cost of bank debt to customer and supplier concentration measures and control variables for Taiwan firms from 2008 to 2019. The dependent variable (*WgtInt*) is the cost of bank debt calculated by weighting the loan amount of the interest rate on bank loans. *SumMajCus* (*SumMajSup*) is the fraction of a firm's total sales to all customers (suppliers) that account for at least 10% of total sales (purchases). *CusHHI* is the customer sales-based Herfindahl-Hirschman Index. *DmajCus* is an indicator variable that is set to one if at least one customer whose sales to total sales account for at least 10% of total sales. *SupHHI* and *DmajSup* are concentration of major suppliers. A customer's or supplier's likelihood of default is captured by Altman's (1968) Z-score. HighBankruptcy (HBP) is an indicator variable that is set to one if the default measure is below the sample median in a given year and zero otherwise. Variables are defined in Appendix A. All specifications include interacted year and industry fixed effects. Continuous variables are winsorized at their 1st and 99th percentiles. Standard errors are corrected for heteroskedasticity and clustering at the supplier level (t-statistics are in parentheses). *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Effect of customer's default probability				
Variable	(1)	(2)	(3)	(4)
SumMajCus	0.0002 (0.69)			0.0002 (0.29)
SumMajCus×HBP	0.0010 *** (3.14)			0.0046 *** (4.64)
SumMajCus ²				-0.00002 (-0.02)
SumMajCus ² ×HBP				-0.0040 *** (-3.69)
CusHHI		0.0005 (1.01)		
CusHHI_HBP		0.0006 *** (2.73)		
DMajCus			0.0001 (0.94)	
DMajCus×HBP			0.0008 *** (3.71)	
HighBankruptcy	0.0015 *** (10.05)	0.0017 *** (13.67)	0.0013 *** (7.07)	0.0012 *** (7.09)
LnTA	-0.0011 *** (-20.16)	-0.0011 *** (-20.38)	-0.0011 *** (-19.89)	-0.0010 *** (-19.59)
TobinsQ	-0.0001 (-1.32)	-0.0001 (-1.19)	-0.0001 (-1.23)	-0.0001 (-1.29)
ROA	-0.0083 *** (-8.86)	-0.0085 *** (-9.16)	-0.0082 *** (-8.86)	-0.0081 *** (-8.67)
LnFixAsset	0.0000 (0.08)	0.0000 (0.08)	0.0000 (-0.12)	0.0000 (-0.12)
DebtRatio	0.0076 *** (20.00)	0.0076 *** (19.92)	0.0076 *** (19.96)	0.0076 *** (19.97)
BoardOW	-0.0031 *** (-7.93)	-0.0031 *** (-7.95)	-0.0031 *** (-7.94)	-0.0031 *** (-7.93)
Constant	0.0431 *** (50.38)	0.0431 *** (50.66)	0.0428 *** (49.32)	0.0428 *** (49.67)
Industry Effect	Yes	Yes	Yes	Yes

Year Effect	Yes	Yes	Yes	Yes
Observations	12,423	12,423	12,423	12,421
Adjusted R ²	0.4180	0.4174	0.4184	0.4193
Panel B: Effect of supplier's default probability				
Variable	(1)	(2)	(3)	(4)
SumMajSup	-0.0005 ** (-2.16)			0.0008 (1.10)
SumMajSup×HBP	0.0014 *** (4.74)			0.0036 *** (3.57)
SumMajSup ²				-0.0013 * (-1.81)
SumMajSup ² ×HBP				-0.0024 ** (-2.29)
SupHHI10		-0.0007 *** (-2.75)		
SupHHI10×HBP		0.0013 *** (3.12)		
DMajSup10			0.0000 (-0.18)	
DMajSup10×HBP			0.0010 *** (4.45)	
HighBankruptcy	0.0012 *** (7.61)	0.0016 *** (11.83)	0.0010 *** (4.74)	0.0010 *** (5.24)
LnTA	-0.0011 *** (-20.10)	-0.0011 *** (-20.38)	-0.0011 *** (-20.05)	-0.0011 *** (-19.94)
TobinsQ	-0.0001 (-1.29)	-0.0001 (-1.07)	-0.0001 (-1.40)	-0.0001 (-1.38)
ROAa	-0.0084 *** (-9.04)	-0.0086 *** (-9.25)	-0.0084 *** (-9.11)	-0.0083 *** (-8.97)
LnFixAsset	0.0000 (-0.11)	0.0000 (-0.23)	0.0000 (-0.05)	0.0000 (-0.31)
DebtRatio	0.0076 *** (19.89)	0.0076 *** (19.92)	0.0076 *** (19.87)	0.0076 *** (19.84)
BoardOW	-0.0031 *** (-8.00)	-0.0031 *** (-7.97)	-0.0031 *** (-8.10)	-0.0031 *** (-8.07)
Constant	0.0433 *** (49.34)	0.0436 *** (50.97)	0.0430 *** (48.99)	0.0431 *** (48.87)
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
Observations	12,423	12,423	12,423	12,421
Adjusted R ²	0.4180	0.4173	0.4184	0.4192

Table 7 Effect of switching costs

This table reports results from OLS regressions relating the cost of bank debt to customer concentration measures and control variables. The dependent variable (*WgtInt*) is the cost of bank debt calculated by weighting the loan amount of the interest rate on bank loans. *SumMajCus* is the fraction of a firm's total sales to all customers that account for at least 10% of total sales. *CusHHI* is the customer sales-based Herfindahl-Hirschman Index. *DmajCus* is an indicator variable that is set to one if at least one customer whose sales to total sales account for at least 10% of total sales. Switching Cost is the firm's total sales divided by the total sales of the supplier's industry code. *LowSwitchingCost* (*LSC*) is an indicator variable set to one if the switching cost is below the sample median in a given year and zero otherwise. All variables are defined in Appendix A. All specifications include interacted year and industry fixed effects. Continuous variables are winsorized at their 1st and 99th percentiles. Standard errors are corrected for heteroskedasticity and clustering at the supplier level (t-statistics are in parentheses). *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Variable	(1)		(2)		(3)		(4)	
SumMajCus	-0.0001 (-0.35)						0.0007 (1.25)	
SumMajCus×LSC	0.0015 (4.68)	***					0.0039 (4.20)	***
SumMajCus ²							-0.0009 (-1.31)	
SumMajCus ² ×LSC							-0.0029 (-2.62)	***
CusHHI			-0.00004 (-0.14)					
CusHHI_LSC			0.0018 (3.32)	***				
DMajCus					0.0002 (1.30)			
DMajCus×LSC					0.0009 (4.76)	***		
LowSwitchingCost	0.0008 (5.21)	***	0.0010 (7.49)	***	0.0007 (3.95)	***	0.0006 (3.68)	***
LnTA	-0.0008 (-14.39)	***	-0.0008 (-14.62)	***	-0.0008 (-14.00)	***	-0.0008 (-13.94)	***
TobinsQ	-0.0002 (-1.85)	*	-0.0002 (-1.76)	*	-0.0002 (-1.82)	*	-0.0002 (-1.85)	*
ROA	-0.0123 (-14.51)	***	-0.0125 (-14.71)	***	-0.0123 (-14.51)	***	-0.0122 (-14.36)	***
LnFixAsset	0.0000 (1.06)		0.0000 (1.12)		0.0000 (0.91)		0.0000 (0.86)	
DebtRatio	0.0082 (21.08)	***	0.0082 (20.99)	***	0.0082 (21.12)	***	0.0082 (21.17)	***
BoardOW	-0.0032 (-8.08)	***	-0.0031 (-8.05)	***	-0.0032 (-8.15)	***	-0.0032 (-8.13)	***
Constant	0.0393 (40.51)	***	0.0395 (40.77)	***	0.0389 (39.33)	***	0.0390 (39.85)	***
Industry Effect	Yes		Yes		Yes		Yes	
Year Effect	Yes		Yes		Yes		Yes	
Observations	12,423		12,423		12,423		12,421	
Adjusted R ²	0.4117		0.4112		0.4119		0.4127	

Table 8 Propensity score matched sample analysis

This table reports results relating the cost of bank debt to customer and supplier concentration measures and control variables. The dependent variable (*WgtInt*) is the cost of bank debt calculated by weighting the loan amount of the interest rate on bank loans. *SumMajCus* (*SumMajSup*) is the fraction of a firm's total sales to all customers (suppliers) that account for at least 10% of total sales (purchases). *CusHHI* is the customer sales-based Herfindahl-Hirschman Index. *DmajCus* is an indicator variable that is set to one if at least one customer whose sales to total sales account for at least 10% of total sales. *SupHHI* and *DmajSup* are concentration of major suppliers. Variables definitions are in Appendix A. All specifications include year and industry fixed effects. Continuous variables are winsorized at their 1st and 99th percentiles. Standard errors are corrected for heteroskedasticity and clustering at the supplier level (t-statistics are in parentheses). *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Customer concentration and cost of bank debt					
Variable	(1)		(2)	(3)	(4)
SumMajCus	0.0010 ***				0.0018 ***
	(4.03)				(2.42)
SumMajCus ²					-0.0010 ***
					(-2.80)
CusHHI10			0.0013 ***		
			(3.04)		
DMajCus10				0.0006 ***	
				(4.2)	
Control Variables	Yes		Yes	Yes	Yes
Industry Effect	Yes		Yes	Yes	Yes
Year Effect	Yes		Yes	Yes	Yes
Observations	6,838		6,838	6,838	6,838
Adjusted R ²	0.4033		0.4027	0.4031	0.4034
Panel B: Supplier concentration and cost of bank debt					
Variable	(1)		(2)	(3)	(4)
SumMajSup	0.0008 ***				0.0029 ***
	(3.07)				(3.59)
SumMajSup ²					-0.0025 ***
					(-2.71)
SupHHI			0.0007 ***		
			(2.97)		
DMajSup				0.0005 ***	
				(3.44)	
Control Variables	Yes		Yes	Yes	Yes
Industry Effect	Yes		Yes	Yes	Yes
Year Effect	Yes		Yes	Yes	Yes
Observations	4,994		4,994	4,994	4,994
Adjusted R ²	0.3741		0.3733	0.3743	0.3751

Table 9 Two-stage least-squares regressions using the instrument variables

This table reports results from two-stage least squares (2SLS) regressions. Results for major customers show in Panel A and B and results of major suppliers show in Panel C and D. Panel A and C report the first-stage results and Panel B and D report the second-stage results. In the first-stage, we regress three major concentration measures on the instrumental variables and on control of firm characteristics. *SumMajCus* is the fraction of a firm's total sales to all customers that account for at least 10% of total sales. *CusHHI* is the customer sales-based Herfindahl-Hirschman Index. *DmajCus* is an indicator variable that is set to one if at least one customer whose sales to total sales account for at least 10% of total sales. *SumMajSup*, *SupHHI*, and *DmajSup* are suppliers' concentration measures. We use industry average concentrations as instrument variables which are one-year lagged industry averages of customer concentrations (*SumMajCus*, *CusHHI*, and *DmajCus*) and supplier concentrations (*SumMajSup*, *SupHHI*, and *DmajSup*) in firms' industry and year (excluding the firm), respectively. In the second stage, we use the predicted value in first-stage as independent variables and control variables to rerun Eq. (7) and (8). Variables definitions are in Appendix A. All specifications include interacted year and industry fixed effects. Continuous variables are winsorized at their 1st and 99th percentiles. Standard errors are corrected for heteroskedasticity and clustering at the supplier level (t-statistics are in parentheses). *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: First-stage results for customer concentration

Variable	SumMajCus (1)	CusHHI (2)	DMajCus (3)	SumMajCus ² (4)
Industry Concentration $t-1$	0.7130 *** (7.43)	0.5804 *** (5.71)	0.7577 *** (8.43)	0.4932 *** (5.49)
Control Variables	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
Observations	12,466	12,466	12,466	12,466
Adjusted R ²	0.0797	0.0361	0.1192	0.0408

Panel B: Second-stage results for customer concentration

Variable	(1)	(2)	(3)	(4)
Predicted SumMajCus	0.0015 *** (3.27)			0.0551 *** (3.17)
Predicted SumMajCus ²				-0.0913 *** (-3.24)
Predicted CusHHI		0.0158 *** (8.26)		
Predicted DMajCus			0.0030 *** (7.14)	
Control Variables	Yes	Yes	Yes	Yes
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
Observations	12,466	12,466	12,466	12,466
Adjusted R ²	0.4033	0.4027	0.4031	0.4034

Panel C: First-stage results for supplier concentration

Variable	SumMajSup (1)	SupHHI (2)	DMajSup (3)	SumMajSup ² (4)
Industry Concentration $t-1$	0.8460 *** (11.59)	1.1409 *** (11.81)	0.7377 *** (8.70)	0.7962 *** (11.65)
Control Variables	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
Observations	12,466	12,466	12,466	12,466

Adjusted R ²	0.1553	0.1454	0.0893	0.1114
Panel D: Second-stage results for supplier concentration				
Variable	(1)	(2)	(3)	(4)
Predicted SumMajSup	0.0049 *** (9.61)			0.1337 *** (8.74)
Predicted SumMajSup ²				-0.1470 *** (-8.43)
Predicted SupHHI		0.0056 *** (10.31)		
Predicted DMajSup			0.0025 *** (4.93)	
Control Variables	Yes	Yes	Yes	Yes
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
Observations	12,466	12,466	12,466	12,466
Adjusted R ²	0.2134	0.2145	0.2085	0.2181

Appendix A. Definition of variables.

Type	Variable	Definition
Dependent variable	WgtInt	WgtInt is the cost of bank debt calculated by weighting the loan amount of the interest rate on bank loans.
Independent variable - Customer	DMajCus	DMajCus is an indicator variable set to one if at least one customer whose sales to total sales account for at least 10% of total sales, and zero otherwise.
	CusHHI	CusHHI is designed for each firm <i>i</i> by summing the squares of the ratios of a firm <i>i</i> 's sales to each major customer <i>j</i> 's total sales in year <i>t</i> .
	SumMajCus	SumMajCus is defined as the fraction of a firm's annual sales that are accounted for by all major customers.
	NumMajCus	NumMajCus is the number of customers whose sales to total sales account for at least 10% of total sales.
Independent variable - Supplier	DMajSup	DmajSup is an indicator variable set to one if at least one supplier whose purchases account for at least 10% of total purchases and zero otherwise.
	SupHHI	SupHHI is designed for each firm <i>i</i> by summing the squares of the ratios of a firm <i>i</i> 's purchases to each major supplier <i>j</i> 's total purchases in year <i>t</i> .
	SumMajSup	SumMajSup is defined as the fraction of a firm's annual purchases that are accounted for by all major suppliers.
	NumMajSup	NumMajSup is the number of suppliers whose purchases to total purchases account for at least 10% of total purchases.
Control variable	LnTA	LnTA = Log(book value of asset)
	TobinsQ	TobinsQ = (book value of total assets + market value of equity – book value of equity) / book value of total assets
	ROA	Return on Assets = net profit/average total assets
	LnFixAsset	LnFixAsset = Log(fixed sssets)
	DebtRatio	DebtRatio = debt / total assets
	BoardOw	BoardOw = board ownership
	Zscore	A customer's or supplier's likelihood of default is captured by Altman's (1968) Z-score. For each firm, we determine which of the firm's identifiable customers or suppliers has the highest probability of default and use this value to proxy for the risk of having a major customer or supplier default.
	LowSwitchingCost (LSC)	SwitchingCost is the supplier's total sales divided by the total sales of the supplier's industry code. LowSwitchingCost (LSC) is an indicator variable set to one if the switching cost is below the sample median in a given year and zero otherwise.
	HighBankruptcy (HBP)	HighBankruptcy (HBP) is an indicator variable that is set to one if the default measure is above the sample median in a given year and zero otherwise.