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The Impact and Mechanism of the COVID-19 Pandemic on Corporate Financing: Evidence from Listed Companies in China

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Abstract: The unexpected emergence of COVID-19 has placed businesses throughout the globe under considerable financial hardship, and financial constraints are a significant barrier to business expansion, particularly in developing countries with insufficient credit markets. Using yearly data for Chinese listed businesses from 367 cities, we examine the impact of COVID-19 on financial restrictions and the corresponding mechanisms of action by using a difference-in-differences (DID) methodology. We discover that COVID-19 leads to a significant increase of 0.117 in the KZ index of listed firms, i.e., an increase in financing constraints, and this result is consistent with various robustness tests. We also show that COVID-19 considerably lowers a company's capacity to obtain external financing by increasing debt costs and deterring commercial credit. The pandemic significantly reduced the company's commercial credit by 0.008 and increased debt costs by 0.2%. Moreover, the data demonstrate variation across industries, business ownership, and firm scale. Our findings indicate that decreasing information asymmetries facilitate successful adaptation to and recovery from external shocks. Our analysis suggests that governments should promulgate policies that are conducive to corporate financing to help companies maintain development during the outbreak of the epidemic and ensure economic sustainability.

Keywords: COVID-19; pandemic lockdown; financial constraints; commercial credit; debt costs

1. Introduction

Financial constraints are a crucial indicator of a company's development process. Much of the literature studies financial restrictions [1–4]. However, numerous external conditions, such as the danger of a COVID-19 pandemic spreading to financial markets, might generate financial hardship for businesses [5]. Enterprises have even more significant funding difficulties in regions where the COVID-19 epidemic is severe [6,7]. Financial limitations hinder company growth and efficiency [8] and R&D investment [9], which are unfavorable to healthy business development.

It is widely acknowledged that the COVID-19 pandemic has led to a significant rise in risk across industries and has had far-reaching effects on transportation, population mobility, healthcare, and economic growth [10,11]. Ultimately, sustainable economic growth is severely compromised [12–14]. Consequently, the influence of the COVID-19 pandemic on financial markets has garnered considerable interest [15]. There has been a dramatic increase in the number of studies examining the impact of the COVID-19 pandemic on financial markets, including market risk [16], stock market volatility [17,18], corporate returns [19], and asset liquidity [20]. In contrast, because of data restrictions, research on the impact of the COVID-19 pandemic on finance constraints is quite limited. As the extent of information asymmetries between banks and businesses rises, banks restrict lending to mitigate risk. Similar restrictions were placed on bond issuance and stock financing to relieve enterprises' financial difficulties [6]. Given the global breakout of public health issues, there is an urgent need to analyse how the COVID-19 pandemic impacts the financial performance of businesses.

As China was the first nation to establish a program to lock down its cities and is the world's largest supplier of intermediate products, it is crucial to analyse Chinese financial markets. China's approach to COVID-19 in terms of monetary policy has been comparable to that of other nations, including initiatives that might cut bank interest rates and increase the availability of money. For instance, during the onset of the COVID-19 epidemic, the Chinese central government released a Circular on Further Improving Financial Services for Disease Prevention recommending using noncontact service channels to alleviate the financial restrictions of businesses. Existing research has shown the consequences of the COVID-19 pandemic in China, such as financial coping measures [21,22] and corporate performance losses [19]. Currently, authors such as Ling [6] and Zhang [11] have analysed the relationship between the COVID-19 epidemic and financial constraints, but their study has two flaws: (1) they used unstable and unreliable quarterly data, and (2) they did not systematically examine how COVID-19 affects financial constraints. This research, therefore, not only provides proof of the effect of the COVID-19 pandemic on the financial performance of enterprises but also shows the transmission mechanism involved.

China's approach to COVID-19 differs significantly from that of other areas. If a city experiences a severe COVID-19 pandemic, that city will perform rigorous case screening or perhaps suspend nonessential economic operations. Additionally, other cities will rigorously regulate population access and resource exchange with towns experiencing significant epidemics. Therefore, the use of different-in-differents (DID) is required to investigate the effects of COVID-19. Using yearly data from publicly traded Chinese enterprises, we discover that the COVID-19 epidemic has worsened funding limitations. Following several robustness tests, the conclusions above still hold. Additional study indicates that the COVID-19 pandemic impacts funding limitations via two channels: commercial credit and bank loans.

This study makes two contributions. First, the paper analyses the impact of the pandemic on enterprises' financial restrictions from the firm's vantage point. Numerous academics have qualitatively analysed the macroeconomic impact of the COVID-19 epidemic on financial and economic markets [23–25]. Scholars are often interested in how pandemics affect stock returns from a micro viewpoint. During the COVID-19 epidemic in India, for instance, Mishra et al. [26] discovered considerably negative stock returns. In addition, Shen et al. [19] and He et al. [27] indicate that this phenomenon of negative stock returns exists in China, albeit heterogeneously across industries. However, stock price volatility results from the unpredictability of corporations' investment and financing methods; thus, we concentrate on the most critical aspect of stock market volatility: corporate finance. Second, this paper makes a novel contribution to the literature by examining the mechanistic rationale behind the COVID-19 pandemic's influence on the financing constraint process and proposing policy implications to enable firms to respond rationally to unforeseen external shocks such as pandemics.

Our findings potentially fill a void in financial economics due to this paper's scientific and rigorous empirical study. Both on a theoretical level and in terms of practical insights, it is an invaluable addition. This study also provides valuable insights into social and economic development and corporate risk management so that those in charge of preventing and mitigating economic losses in the face of severe disasters have some theoretical advice. Between November and December 2022, the central government of China established a strategy to relax the management of epidemics, and both the national and local governments removed limitations on regional travel.

The rest of this paper is organized as follows. The Section 2 describes the literature review and theoretical hypotheses; the Section 3 introduces the data sources and estimation; the Section 4 presents the results of the empirical analysis and robustness test; the Section 5 explores the heterogeneous effects of COVID-19 on financial constraints; the Section 6 discusses potential mechanisms; and the Section 7 contains the conclusion.

2. Literature Review and Hypothesis

2.1. The Pandemic and Financial Constraints

In two ways, the COVID-19 pandemic has impacted the functioning of businesses. First, the pandemic has had a significant impact on the financing behavior of firms and investors [11,19,28], causing sharp fluctuations or even significant declines in stock markets and altering investors' trading strategies [29]. Second, pandemic-resistant measures have drastically restricted the flow of production inputs and impacted financial markets. China, for instance, implemented several measures to prevent the spread of the virus, such as encouraging residents to go out less, encouraging home isolation, increasing social distance, and reducing crowding [18,30], resulting in a decline in the supply of labor factors and undermining the normal functioning of firms [31]. SARS (severe acute respiratory syndrome) affected Asian economies in 2003, with governments and people reducing the movement of people to stop the spread of the virus, thereby reducing demand for services, production, and investment, ultimately resulting in export disruptions, rising unemployment, and a deterioration of the fiscal and financial environment [32].

After China pressed the "Stop" button, the drop in productivity led to a decline in capital markets, and many businesses were forced to confront the reality of being unable to sell their products. According to studies, enterprises in industries more susceptible to the COVID-19 pandemic experienced severe financial difficulties and decreased asset returns during the outbreak [21]. A considerable number of food and beverage enterprises, for instance, ceased operations due to COVID-19 [6]. As a consequence of the extensive effects of COVID-19, many businesses are suffering financial hardship and are confronted with significant funding gaps. In certain severely impacted nations, firms face the possibility of reduced financial flexibility and higher lending costs, resulting in tighter financing limits [33]. However, regular maintenance expenditures and interest on loans did not provide relief, and many firms only had sufficient cash flow to operate them for one quarter. In response to production disruptions, there was great uncertainty over companies' growth potential and operational efficiency, resulting in significant mood swings among investors. Fears of a pandemic caused investors to be even more gloomy about the future and unwilling to invest in enterprises. In addition, the overall fall in financial market confidence can significantly impact external financial choices such as bank lending [34]. Since the beginning of 2020, the COVID-19 epidemic has expanded internationally. As a result, businesses face heightened uncertainty [35], influencing their short-term and even long-term financing behavior [36]. As a result, lenders are expected to evaluate loan risks more thoroughly, resulting in increased financial constraints for businesses. Based on the study presented above, we offer Hypothesis H1:

Hypothesis 1 (H1). *The COVID-19 pandemic has imposed severe financial constraints on Chinese listed companies.*

2.2. Commercial Credit, Debt Costs and Financial Constraints

Although we can determine that COVID-19 affects corporate finance, we are more interested in its method of action and the specific transmission pathways and mechanisms it affects. Companies and governments that face unexpected external shocks would benefit from additional research into the factors involved. If enterprises understand how COVID-19 affects their financing situation, they can take the initiative to clear the obstacles in the financing channel. If the government comprehends the transmission mechanism, it can enact appropriate policies to alleviate enterprises' financing constraints. To achieve this objective, a comprehensive examination of the topic of this paper is needed. We intend to investigate the factors behind COVID-19's impact on corporate finance and provide relevant insights.

Companies typically have two kinds of financing: internal funding and external financing [37]. External financing refers to financial support from financial institutions and other investors, such as loans, debt issues, and share increases. According to pecking order

theory [38], financing costs rise as information asymmetry grows; therefore, businesses often finance themselves internally before obtaining external financing. Due to the early underdevelopment of commercial banks and weak financial markets, Chinese companies rely extensively on internal financing, mainly nonstate-owned corporations [39–41]. With the introduction of improved information technology to financial markets and the quick upgrading of financial instruments, financial institutions are now better able to analyse, monitor, and regulate the potential risks posed by business activity. Consequently, external funding has become businesses' primary source of financing [42]. In addition, we will examine the connection between the COVID-19 epidemic and foreign funding.

The existence of information asymmetry between investors and firms is a primary reason firms experience external financial constraints [43–45]. When firms face catastrophic events, the firm's financing channel may become negative [46]. For instance, the extensive spread of the COVID-19 epidemic enhanced information asymmetries, exacerbating external finance limitations [35]. Investors rely on extensive and SOFT information supplied by corporations when engaging in credit activity, hence decreasing information asymmetries [47]. Therefore, the greater the amount of information asymmetry, the more challenging it is for businesses to gain access to capital [30,48]. Commercial credit can counteract the negative impacts of information asymmetry [49]. Nevertheless, debt costs are the price of financing on the financial market and can indicate the degree of information asymmetry [50].

There is evidence of a positive association between commercial credit and financing limitations on the one hand [49,51]. Commercial credit, which consists of accounts payable, bills payment, and advance receipts, is an informal type of external financing. Allen et al. [40] analysed the evolution of the formal and informal sectors in China. They determined that many successful enterprises in the informal sector did not use any official sources of financing at various phases of their development. These companies relied on alternative private funding sources, such as credit and debit accounts with business partners and other companies. Although this informal financing is only a supplementary method to alleviate the shortage of funds for businesses, it has gained a great deal of importance and popularity in China [52], making commercial credit essential to the study of the COVID-19 pandemic's effects on financial constraints. A perfect indicator of external financial limitations has assessed the difficulty of enterprises in obtaining loans [45]. In general, the greater the cost of loans, the greater the difficulty of obtaining loans. The greater the degree of funding restriction, the greater the sensitivity of bank borrowing to external uncertainty [53]. The rapid COVID-19 epidemic has led to a rise in nonperforming loans in all parts of the globe [54]. To avoid future risk or compensate for it, banks were compelled to drastically limit credit lending and increase enterprises' debt costs [55], imposing further external financing restraints on businesses. In addition, there is a substitution connection between commercial credit and bank loans [56]; therefore, assessing the influence of external uncertainties and financing limitations is impossible without considering debt costs. Based on the above study, we offer the second and third hypotheses:

Hypothesis 2 (H2). *The COVID-19 pandemic has negatively impacted the commercial credit of companies, thereby affecting financial constraints.*

Hypothesis 3 (H3). *The COVID-19 pandemic has made borrowing more expensive for companies, affecting financial constraints.*

3. Data and Estimation

3.1. Data Source

As mentioned above, the Chinese financial market is our research sample, so we use data from Chinese listed companies. The COVID-19 pandemic first broke out in China in 2020, and China was the first country to take action against the pandemic and put its cities under lockdown. To determine how the COVID-19 pandemic has affected firms'

financial constraints, we collected data from the China Stock Market & Accounting Research Database (CSMAR). We used information such as company name, stock code, industry and address to match with data published by the Chinese government on new cases of COVID-19. This resulted in an unbalanced panel of 369 cities and 3870 listed companies from 2011 to 2021. During the sample processing, we removed some data: (1) financial and insurance sectors; (2) missing dependent and control variables; (3) companies marked as special treatment by the stock exchange; and (4) gearing ratios less than 0 or greater than 1. All continuous variables have been truncated by 1% at both ends to avoid the effect of abnormal extreme values.

Our data have the following essential features. First, our database is comprehensive, and the large sample reduces the probability of estimation bias. Second, our sample contains various variables, including firm characteristics and financial data. Therefore, we can analyse more mechanisms in our identification strategy and better overcome the problem of omitted variables. Third, more comprehensive annual data exclude many cyclical effects on quarterly trends.

3.2. Measurements of Financial Constraints

Our study's dependent variable is the finance restriction at the company level. Fazzari et al. [57] initially presented the topic of financial restrictions, and various scientists have subsequently investigated it. For instance, researchers have officially characterized finance restrictions as the difference between internal and external financing costs due to market failures such as information asymmetry and agency costs [58–60]. Typically, two indicators are used to examine finance constraints. The first category consists of the cash flow sensitivity of investments (CFSI) and the cash flow sensitivity of cash (CFSC), where the investment or cash holding variable is dependent and cash flow is independent. Cash sensitivity coefficients are derived following regression, with more significant coefficients indicating worse financing ability [61–64]. The second category of portfolios based on company characteristics includes, among others, the KZ index [60,65], the WW index [66], the SA index [67], and the FC index [68,69]. The second category of indicators was utilized for our baseline regressions and robustness testing due to the following factors. First, it is challenging to quantify firm-level funding limitations using CFSI and CFSC, and second, the interpretation of these indicators is ambiguous, i.e., contentious. Second, the combination of company characteristics constructs incorporates financing limits based on the firm's financial data, which is more prominent and fair.

Cash flow and cash on hand are frequently employed as indications of the degree of internal financing. A high cash flow and cash on hand indicate fewer financing limitations [70]. Denis and Sibilkov [71] contend that enterprises confronting high external financing costs deliberately acquire internal capital, but inside financially constrained firms, increased cash holdings are a response to high external financing costs [72,73]. Consequently, cash indicators are unsuitable for gauging companies with funding challenges.

In conclusion, we employ the KZ index, the SA index, the WW index, and the FC index to assess company financial constraints in several dimensions; all four indices are positively connected with business financial constraints, and their respective computations are provided in the Appendix A. The KZ index is utilized for benchmark regressions, heterogeneity analysis, and mechanism testing, whereas the remaining indices are utilized for robustness tests.

3.3. Measurements of COVID-19

The study in this paper focuses on the impact of COVID-19 on business financing; therefore, the definition of the COVID-19 pandemic is essential. For the measurement of COVID-19, we use two city-level variables: average daily new cases during the year (NewCasess) and average daily cumulative confirmed cases during the year (SumCasess). City-level COVID-19 pandemic data were chosen because China has implemented its epidemic prevention policies on a city-by-city basis. It makes more sense and is correct

for enterprises within the same city to be in the same group. In addition, in managing outbreaks in cities in China, it is common to distinguish whether a city is a high-risk area based on whether the number of new cases of the COVID-19 pandemic or the cumulative number of confirmed cases exceeds the critical values. Therefore, we use a similar approach to identify COVID-19 pandemics, i.e., we use the threshold of the number of cases to distinguish between areas with and without a severe epidemic. The critical values for NewCasess and SumCasess are 1 and 500, respectively. It is worth noting that NewCasess is the core explanatory variable in this study. SumCasess was used for robustness testing.

3.4. Control Variables

Additionally, we analyse a variety of control variables that may influence a company's capacity to obtain capital. After reviewing prior research [74–77], this study controls for the following variables: firm size (Size), sales growth rate (Growth), gearing ratio (Lev), share of net fixed assets (Fix), return on assets (Roa), shareholding of the largest shareholder (Share), state-owned enterprise (Soe), and Tobin's Q. (TQ). In addition, to prevent unobserved and uncontrolled variables from influencing our results, we control for year fixed effects (Year), city fixed effects (City), industry fixed effects (Industry), and firm fixed effects (Firm), as well as standard errors clustered at the firm level for all regressions. The descriptive statistics for the variables analysed in this paper are presented in Table 1, and the detailed data are provided in Appendix A.

Table 1. Summary statistics.

Variable	Description	Obs.	Mean	Std. Dev
	Dependent variables			
KZ	Financial constraints: KZ index	28,408	0.990	2.449
SA	Financial constraints: SA index	28,408	−3.812	0.265
WW	Financial constraints: WW index	24,238	−1.245	30.45
FC	Financial constraints: FC index	28,408	0.485	0.283
	Independent variable			
NewCases	Dummy variable: whether the average daily new Casess during the year is more than 1	28,408	0.0661	0.249
SumCases	Dummy variable: whether the average daily sum Casess during the year is more than 500	28,408	0.0769	0.266
	Control variables			
Size	Firm size: the logarithm of total assets	28,408	22.27	1.333
Growth	Firm Sales growth rate: (current sales−previous sales)/ current sales	27,978	0.349	12.82
Lev	Firm leverage: total liabilities/total assets	28,408	0.427	0.206
Fix	Firm proportion of net fixed assets: net fixed assets/ total assets	28,408	0.212	0.162
Roa	Firm return on total assets: net profit/ total assets	28,408	0.035	0.084
Share	Shareholding ratio of the largest shareholder	28,274	0.366	0.482
Soe	Dummy variable: whether firm is state-owned enterprise	28,274	0.344	0.151
TQ	Tobin's Q: firm's market value/ asset replacement cost	28,408	2.152	5.038
	Mediating variables			
CC	Commercial credit: (bills payable + accounts payable + deposit received)/total assets	28,408	0.156	0.116
DC	Debt costs: (financial cost)/total debt	28,408	0.005	0.055

3.5. Identification Strategy

Section 3.3 defines a measure of COVID-19, with the emergence of pandemic-hit areas starting in 2020. To explore the gap between the treatment and control groups, we use a DID model to estimate the effect of the COVID-19 pandemic on firms' financial constraints. Below is the model we used, where c, i and t represent firm, region and time, respectively, and $\varepsilon_{i,t}$ is the random error terms of the model. FC and Covid are the financing constraints and the dummy variable representing the epidemic's severity, respectively. The Covid variable is equal to 1 if the epidemic is severe at the stated period and location and 0 otherwise. This is based on the strategies of Ling and Zhang [6,11]. Such an empirical model can accurately compute the variation between regions with different epidemic circumstances at the same time, as well as the variation between the same region at different times, and ultimately determine the influence of the epidemic's severity on the financing of regional enterprises. Additionally, we include firm, industry, time, and area fixed effects in our model to eliminate the influence of unobserved variables on our findings.

$$FC_{c,i,t} = \beta_0 + \beta_1 Covid_{c,i,t} + \sum_j \gamma_j Control_j + Firm_c + Industry_c + City_i + Year_t + \varepsilon_{c,i,t} \quad (1)$$

3.6. Mediating Effect Model

To test the mechanism of the effect of COVID-19 on corporate financial constraints, we develop a mediating effects model. We use the two mediating variables illustrated in Table 1: business credit (CC) and cost of debt (DC). The model is as follows:

$$M_{c,i,t} = \sigma_0 + \alpha_1 Covid_{c,i,t} + \sum_j \gamma_j Control_j + Firm_c + Industry_c + City_i + Year_t + \varepsilon_{c,i,t} \quad (2)$$

$$FC_{c,i,t} = \sigma_1 + \alpha_2 Covid_{c,i,t} + \alpha_3 M_{c,i,t} + \sum_j \gamma_j Control_j + Firm_c + Industry_c + City_i + Year_t + \varepsilon_{c,i,t} \quad (3)$$

where M is the intermediate variable (CC and DC), and the test procedure follows. In Step 1, we use Equation (1) to test whether the coefficient β_1 of COVID-19 is significant. If the coefficient is significantly positive, then COVID-19 increases the financing constraint. Step 2 continues with Equations (2) and (3) to test whether the coefficients α_1 and α_3 are significant. If both indicate a significant effect of COVID-19 on the mediating variable, proceed to step 4. However, if at least one is not significant, go to step 3. Step 3 is a direct bootstrap test for H0: $\alpha_1 \times \alpha_3 = 0$. If the indirect effect is significant, we proceed to step 4; otherwise, the analysis is stopped. In step 4, we check whether the coefficient α_2 is significant. If not, the direct effect is insignificant and only a mediating effect. If the direct effect is significant, a comparison between the signs $\alpha_1 \times \alpha_3$ and α_2 needs to be completed. A partial mediating effect can be identified when the absolute value of the total effect β_1 is greater than the absolute value of the direct effect α_2. The proportion of the mediating effect to the total effect can be expressed as $(\alpha_1 \times \alpha_3)/\beta_1$. Conversely, a masking effect is indicated if it indicates the opposite sign and the absolute value of β_1 is less than the absolute value of α_2.

4. Empirical Analysis

4.1. Trend of Financial Constraints

Before starting the regression analysis, it would be prudent to investigate the patterns in business funding restrictions before and after the COVID-19 epidemic. From 2016 through 2021, Figure 1 depicts parallel trends in KZ indices for the treatment and control groups. The horizontal axis represents the year, and the vertical axis represents the KZ index for that year. The solid line represents the average KZ index for the treatment group, whereas the dashed line represents the average KZ index for the control group. The vertical dashed COVID-19 pandemic divider line illustrates the trend in the KZ index before and after the outbreak. As seen by the graph, there is minimal variation between the mean financial restrictions of the two groups before the outbreak. After the onset of the pandemic, the KZ index disparity between the treatment and control groups began

to widen. This graph provides crucial proof that the COVID-19 epidemic significantly impacted financial services.
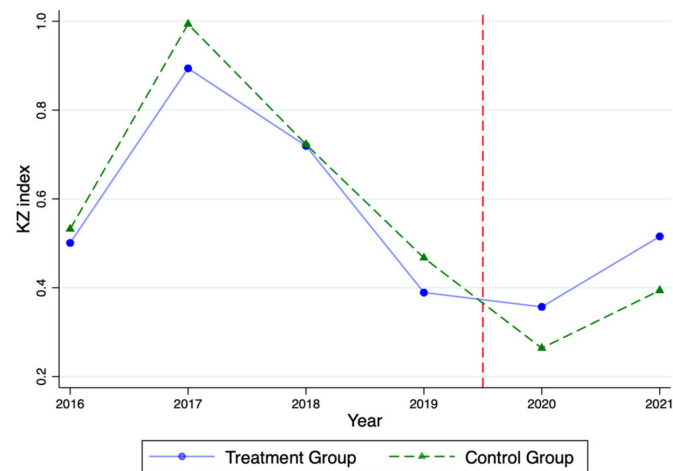

Figure 1. Trend of the KZ index.

To further illustrate that the COVID-19 epidemic has had a significant detrimental influence on company growth, we mapped the average ROA of the firms. Figure 2 depicts the ROA trend for the treatment and control groups from 2016 to 2021. The solid line represents the average ROA for the treatment group, whereas the dashed line represents the average ROA for the control group. The vertical dashed COVID-19 pandemic divider line illustrates the trend in the KZ index before and after the outbreak. As shown by the graph, the difference in mean ROA between the two groups prior to the arrival of COVID-19 is more consistent (until 2019, when the control group experienced a fall), and the mean value is more significant in the treatment group than in the control group. After the pandemic, however, this scenario flipped, with ROA remaining nearly unchanged for enterprises in the treatment group, while firms in the control group experienced a significant increase. This is presumably due to a change in market demand from enterprises in the treatment group to those in the control group due to the pandemic shock and the accompanying boost to the control group. Thus, it is evident that the entrance of COVID-19 had a significant negative influence on businesses in regions with severe pandemics, which we will continue to explore using data and model regressions in the following section.
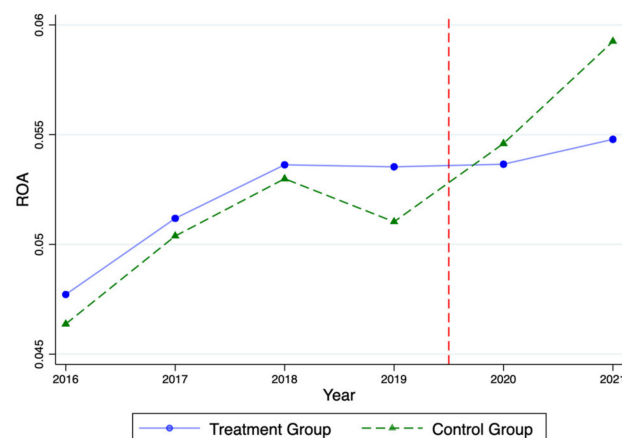

Figure 2. Trend of ROA.

4.2. Baseline Results

Using Equation (1), we estimate the outcomes of our baseline regression and present them in Table 2. As an explanatory variable, the KZ index shows the degree of financing

limitations experienced by the company, with a higher KZ index indicating lower corporate financing capability. Each column represents a different regression. We begin the estimate with an HDFE linear regression with fixed effects in Column (1). We discover that COVID-19 significantly increases the difficulty of funding businesses. We provide control variables in Column (2), which controls for shocks to observable variables that influence finance restrictions. The coefficient of the difference between COVID-19 is consistently positive and statistically positive at the 1% level. To better highlight the impact, columns (3), (4), and (5) include industry fixed effects, city fixed effects, and year fixed effects in that order. With a marginal effect of 0.117 or 16.13% of the mean, COVID-19 considerably impacts enterprises' funding restrictions. Overall, the data presented in Table 2 support hypothesis 1 that the influence of COVID-19 increases enterprises' funding constraints.

Table 2. The impact of COVID-19 on financial constraints: baseline results.

	(1)	(2)	(3)	(4)	(5)
			Financial Constraints = KZ		
NewCases	0.096 *	0.104 **	0.110 ***	0.109 ***	0.117 **
	(0.050)	(0.041)	(0.042)	(0.042)	(0.046)
Size		−0.625 ***	−0.630 ***	−0.629 ***	−0.437 ***
		(0.030)	(0.031)	(0.032)	(0.042)
Growth		−0.109 ***	−0.108 ***	−0.114 ***	−0.163 ***
		(0.033)	(0.032)	(0.033)	(0.032)
Lev		7.668 ***	7.625 ***	7.648 ***	7.344 ***
		(0.161)	(0.159)	(0.160)	(0.160)
Fix		1.808 ***	1.926 ***	1.969 ***	2.644 ***
		(0.187)	(0.189)	(0.191)	(0.188)
Roa		−12.173 ***	−12.191 ***	−12.172 ***	−14.094 ***
		(0.624)	(0.619)	(0.625)	(0.702)
Soe		0.318 ***	0.340 ***	0.333 ***	0.209 **
		(0.106)	(0.104)	(0.106)	(0.094)
Share		−1.270 ***	−1.281 ***	−1.250 ***	−1.069 ***
		(0.226)	(0.230)	(0.233)	(0.217)
TQ		0.142 ***	0.144 ***	0.143 ***	0.279 ***
		(0.024)	(0.023)	(0.023)	(0.043)
Constant	0.744 ***	11.811 ***	11.905 ***	11.859 ***	7.380 ***
	(0.003)	(0.687)	(0.716)	(0.729)	(0.955)
Observations	24,675	24,573	24,571	24,568	24,568
R-square	0.610	0.721	0.724	0.725	0.768
Firm fixed affects	Yes	Yes	Yes	Yes	Yes
Industry fixed affects	No	No	Yes	Yes	Yes
City fixed affects	No	No	No	Yes	Yes
Year fixed affects	No	No	No	No	Yes

Notes: In all regressions, the standard errors in parentheses are grouped by firm. ***, ** and * are significant at the 1%, 5% and 10% levels, respectively. R-square is the within-group R-square.

4.3. Robustness Test

4.3.1. Change the Measurement of COVID-19

First, we replaced the quantitative criteria for the COVID-19 pandemic from NewCases for cities to SumCases for each city. Column (1) in Table 3 does not include the same control variables as the benchmark regression, and column (2) does to ensure the robustness of this result. The results in Table 3 show that the dummy variable constructed using the cumulative number of confirmed cases has a significant impact on the financing constraint at the 1% level and is not significantly different from the results of the benchmark regression. This demonstrates the robustness of the results from the benchmark regression.

Table 3. Change the Measurement of COVID-19.

	(1)	(2)
	Financial Constraints = KZ	
SumCases	0.170 ***	0.132 ***
	(0.063)	(0.049)
Observations	24,670	24,568
R-square	0.646	0.768
Controls	No	Yes
Firm fixed affects	Yes	Yes
Industry fixed affects	Yes	Yes
City fixed affects	Yes	Yes
Year fixed affects	Yes	Yes

Notes: In all regressions, the standard errors in parentheses are grouped by firm. *** is significant at the 1% levels, respectively. R-square is the within-group R-square.

4.3.2. Change the Measurement of the Financial Constraints

To further test the robustness of our study, we use several canonical financing constraint indicators in place of the dependent variable, namely, the SA index, WW index, and FC index mentioned earlier. These indicators have been adopted in numerous papers and studies, suggesting that using these indices is justified [65,66]. The specific results are displayed in Table 4, with all regression procedures incorporating control variables consistent with the baseline regression and controlling for firm, industry, city and year fixed effects.

Table 4. Change the Measurement of the Financial Constraints.

	(1) Financial Constraints = SA	(2) Financial Constraints = WW	(3) Financial Constraints = FC
NewCases	0.006 ***	0.003 **	0.016 ***
	(0.002)	(0.001)	(0.004)
Observations	24,568	20,538	24,568
R-square	0.971	0.908	0.915
Controls	Yes	Yes	Yes
Firm fixed affects	Yes	Yes	Yes
Industry fixed affects	Yes	Yes	Yes
City fixed affects	Yes	Yes	Yes
Year fixed affects	Yes	Yes	Yes

Notes: In all regressions, the standard errors in parentheses are grouped by firm. *** and ** are significant at the 1% and 5% levels, respectively. R-square is the within-group R-square.

Consistent with the KZ index, the giant SA, WW and FC indices represent higher financial constraints for firms. As we can see from the results in Table 4, the regression results after replacing the dependent variable indicators are all significant and positive, with the significance level of the effect of the COVID-19 shock on the SA and FC indices being at 1% and the significance level of the effect on the WW index being at 5%. The results in Table 4 provide further evidence of the reliability and credibility of our study.

5. Heterogeneity Analysis

The above findings suggest that the emergence of the COVID-19 pandemic has increased the financial constraints of firms. However, different types of firms may react differently and have different levels of financial constraints under a pandemic. Further understanding of these differences helps us to obtain a complete picture of the impact of the COVID-19 pandemic on corporate finance. Therefore, we further analyse below whether there are differences in the financial constraints of different firms under COVID-19 and the magnitude of the differences. If the impact of COVID-19 on corporate finance is heterogeneous, we can avoid risks accordingly based on these findings. Specifically, the

government can provide policy protection and support to selected industries, allowing businesses to comprehend their exit and respond promptly.

5.1. Primary, Secondary and Tertiary Industries

Industrial economics categorizes all listed firms' industries into three major categories: primary, secondary, and tertiary. The primary component of the tertiary industry is services. Thus, primary industry enterprises (PIEs), secondary industry enterprises (SIEs), and tertiary industry enterprises (TIEs) have different product characteristics and production processes and are not evenly impacted by COVID-19. In light of COVID-19, we contend that the funding limitations in the three industries will likewise vary. Using the three businesses as divisions, we independently investigate the impact of the COVID-19 pandemic on financial services. Table 5 provides the results.

Table 5. Primary, secondary and tertiary industries.

	(1) PIEs	(2) SIEs	(3) TIEs	(4) TCREs
	Financial Constraints = KZ			
NewCases	0.092	0.170 ***	−0.068	0.352 *
	(0.398)	(0.055)	(0.087)	(0.207)
Observations	270	17,981	6215	1361
R-square	0.768	0.778	0.756	0.258
Controls	Yes	Yes	Yes	Yes
Firm fixed affects	Yes	Yes	Yes	No
Industry fixed affects	Yes	Yes	Yes	Yes
City fixed affects	Yes	Yes	Yes	Yes
Year fixed affects	Yes	Yes	Yes	Yes

Notes: In all regressions, the standard errors in parentheses are grouped by firm. *** and * are significant at the 1% and 10% levels, respectively. R-square is the within-group R-square. Individual firm effects were not included in the analysis of TCREs in column (4) because these firms were considered to be free of interindividual differences in the analysis process.

Table 5 demonstrates that the COVID-19 pandemic likely did not significantly impact the PIEs because the primary industry is very cyclical, their demand is reasonably constant, and the pandemic minimally impacts their production process and production environment in q. The primary reasons for this are that the secondary industry requires a large amount of capital and labor, that COVID-19 reduced labor mobility, thereby rendering production unsustainable, and that the pandemic brought a great deal of uncertainty and risk to the financial markets, causing cautious investment behavior.

Last, the TIEs do not demonstrate any significant shift in funding limitations, which is surprising. Since the COVID-19 epidemic has had a substantial impact on tourist, catering, and retailing businesses (TCREs), it would be logical for the coefficient on TIEs to be significantly positive.

In 2020, however, statistical studies indicated that the overall assets of TCREs would be approximately 2.59 trillion yuan. In contrast, the total assets of TIEs will be approximately 21.26 trillion yuan or a meagre 12.18 percent. In addition, we generate a subsample of TCREs for the regression and provide the findings in Table 5, column 4. This demonstrates that the influence of the pandemic on the funding restrictions of TCREs is still substantial, i.e., COVID-19 decreases the financing capacity of TCREs, which is consistent with reality. The coefficient for TIEs does not appear statistically significant, suggesting that most TIEs are in the service industry and can operate online. While the pandemic has curtailed labor mobility, the current Internet has evolved so swiftly that the COVID-19 shock effect has no impact on TIEs.

5.2. State-Owned Enterprises vs. Nonstate-Owned Enterprises

The ownership structure of Chinese businesses is distinctive in that it is a system of multiple ownership with many state-owned enterprises (SOEs) and non-SOEs (non-SOEs). SOEs have better capital and labor resource advantages than non-SOEs. We propose that SOEs are better prepared for a large contingency such as COVID-19, as the magnitude of change in funding limitations for SOEs will be less than for non-SOEs.

During our sample period of 2011 to 2021, certain businesses undergo ownership changes; hence, we remove those firms. The results are shown in Table 6. After the COVID-19 pandemic, we find that SOEs are less limited by finance than non-SOEs. Even while SOEs display an enhanced degree of funding restriction of 0.09 during the pandemic, this is still less than the marginal effect of the entire sample (0.117), and the finding is not statistically significant. Non-SOEs, on the other hand, underperformed following the epidemic, with a 0.132 increase in funding restriction. This might be explained by the fact that government-backed SOEs have stronger credit guarantees, causing investors to consider them less risky. In contrast, the performance of non-SOEs during the COVID-19 pandemic, lacking sufficient cash and favorable lending regulations to maintain them through the epidemic, further diminished their access to financial services.

Table 6. State-owned Enterprises vs. Nonstate-owned Enterprises.

	(1) SOEs	(2) Non-SOEs
	Financial Constraints = KZ	
NewCases	0.090	0.132 **
	(0.071)	(0.061)
Observations	8456	14,607
R-square	0.788	0.752
Controls	Yes	Yes
Firm fixed affects	Yes	Yes
Industry fixed affects	Yes	Yes
City fixed affects	Yes	Yes
Year fixed affects	Yes	Yes

Notes: In all regressions, the standard errors in parentheses are grouped by firm. ** are significant at the 5% levels, respectively. R-square is the within-group R-square.

5.3. Small-Scale Enterprises vs. Large-Scale Enterprises

There are small-scale businesses (SSEs) and large-scale enterprises (LSEs) under the categorization of firms (LSEs). This is because, among the numerous businesses, some are very large, and others are very small. Even during the COVID-19 outbreak, LSEs have easier access to capital because of their greater influence and credibility in the business and financial markets. In contrast, SSEs may have insufficient information to provide to investors, and COVID-19 may increase their risk of insolvency, limiting their access to financial services. Therefore, we define businesses as LSEs based on their average size over the sample period. Those larger than or equal to the median are classified as LSEs, and those more minor than the median are classified as SSEs.

Table 7 confirms the conclusion above, showing that the financing limitation for SSEs relative to LSEs increased by 0.188 units in response to the COVID-19 shock, exceeding the entire sample level (0.117). In contrast, the degree of funding limitation for LSEs is significantly lower than for SSEs and the sample average. This result implies that the strengths of LSEs had a significant impact on facilitating access to financial services in the face of the epidemic.

Table 7. Small-Scale Enterprises vs. Large-Scale Enterprises.

	(1) SSEs	(2) LSEs
	Financial Constraints = KZ	
NewCases	0.188 **	0.094 *
	(0.095)	(0.052)
Observations	9242	14,881
R-square	0.785	0.792
Controls	Yes	Yes
Firm fixed affects	Yes	Yes
Industry fixed affects	Yes	Yes
City fixed affects	Yes	Yes
Year fixed affects	Yes	Yes

Notes: In all regressions, the standard errors in parentheses are grouped by firm. ** and * are significant at the 5% and 10% levels, respectively. R-square is the within-group R-square.

6. Possible Mechanisms

Regarding financial limitations, the data presented in Section 5 imply that COVID-19 shocks can have varied consequences on various types of enterprises. However, how a COVID-19 pandemic affects finance restrictions is a further concern of equal significance. This topic significantly reduces the transmission of risk associated with severe health catastrophes. Therefore, we further investigate below the processes through which the COVID-19 pandemic influences the funding restrictions of businesses.

6.1. Commercial Credit (CC)

The previous section of the theoretical analysis demonstrated that CC could mitigate the negative impact of information asymmetry on financial constraints [49,56,76,78], so CC is likely one of the mechanisms through which COVID-19 affects firms' financial constraints. Good commercial credit is a signal that businesses convey to investors and bondholders, making it more straightforward for them to obtain external funding. In contrast, a firm's commercial credit is susceptible to a shock during an epidemic, which finally leads to financing limits. To investigate this process, we estimate the influence of COVID-19 on mediating variables using the DID framework of Equation (1), with CC as the mediating variable. We utilize the theory presented in Section 3.6 to analyse the mediating effects of this investigation. The outcomes of Step 1 are displayed in Table 2. Thus, they are omitted here. The outcomes of Step 2 are displayed in column (1) of Table 8, where COVID-19 considerably impacts the firm's CC. Meanwhile, the findings in column (2) reflect the outcomes of Step 4, in which both new cases and CC are incorporated into the regression model simultaneously at a significance level of 1%. This study demonstrates that the COVID-19 epidemic reduces enterprises' capacity to raise capital by lowering their CC; that is, the theoretical Hypothesis H2 of this paper is proven.

6.2. Debt Costs (DC)

DC is a significant element in addition to the close relationship between CC and finance limitations. External borrowing is a significant source of financing for businesses. Enterprises will select an alternative channel if CC is compromised—a bank loan [79]— since it may significantly alleviate the current financing restriction [80]. In contrast, growth in DC is likely to cause financial issues for companies. Therefore, we feel it is vital to investigate whether the COVID-19 pandemic impacts financial restrictions via debt costs. To investigate this process, we employ the DID framework of Equation (1) for steps 2 and 4 in Section 3.6, where DC is regarded as an intermediate outcome variable, and the outcomes of steps 2 and 4 are displayed in Table 8, columns (3) and (4), respectively. Similarly, the data suggest that the COVID-19 epidemic has increased enterprises' costs of obtaining loans, increasing the number of financing limitations for businesses. To summarize the results of Table 8, the COVID-19 epidemic not only harms the CC of enterprises but also

raises their DC, leading to the problem of financing limits for businesses. This in turn tests the validity of the theoretical Hypothesis H3 in this paper.

At the moment, all three research hypotheses of the theoretical hypothesis have been fully demonstrated, and Table 9 demonstrates their demonstration level. The first column of the table indicates the core variables in each hypothesis; the second column indicates the degree of influence of COVID-19 on them; the third column indicates the significance level of the respective research hypothesis; the fourth column indicates the sample size for testing the hypothesis. The fifth column indicates whether the respective research hypothesis was accepted or rejected.

Table 8. Mechanism analysis.

Dependent Variable:	(1) CC	(2) KZ	(3) DC	(4) KZ
NewCases	−0.008 ***	0.103 **	0.002 **	0.109 **
	(0.003)	(0.046)	(0.001)	(0.046)
CC		−1.649 ***		
		(0.246)		
DC				3.539 ***
				(0.429)
Observations	24,568	24,568	24,568	24,568
R-square	0.837	0.769	0.489	0.772
Controls	Yes	Yes	Yes	Yes
Firm fixed affects	Yes	Yes	Yes	Yes
Industry fixed affects	Yes	Yes	Yes	Yes
City fixed affects	Yes	Yes	Yes	Yes
Year fixed affects	Yes	Yes	Yes	Yes

Notes: In all regressions, the standard errors in parentheses are grouped by firm. *** and ** are significant at the 1% and 5% levels, respectively. R-square is the within-group R-square.

Table 9. Mechanism analysis.

Variables	Extent of Impact	Significance Level	Observations	Acceptance or Rejection
KZ index	0.117	**	24,568	Acceptance
Commercial Credit (CC)	−0.008	***	24,568	Acceptance
Debt costs (DC)	0.002	**	24,568	Acceptance

Notes: In all regressions, the standard errors in parentheses are grouped by firm. *** and ** are significant at the 1% and 5% levels, respectively. R-square is the within-group R-square.

7. Discussion

Nowadays, sustainability is an essential business quality. Thus business scholars and managers are concerned about several external contingencies. This study presents several findings and aims to summarise how and to what extent the COVID-19 epidemic has affected businesses; these findings can inform future research. This article explores firm-level financial performance using yearly data from listed Chinese enterprises from 2011 to 2021 to comprehensively evaluate the impact of the COVID-19 epidemic on firms' financing limitations and then analyzes the diverse impacts and decomposes the underlying causes, these results can provide recommendations for future research.

This study is based on five significant aspects that are the subject of this investigation. First, in the aftermath of the COVID-19 epidemic, many scholars and professionals have examined the pandemic's effects, including the viability of businesses, stock market fluctuations, changes in financial position, and labour migration. There was significant interest in determining the positive and negative effects of the pandemic in order to determine the most effective company management strategy. Although we are now in a post-pandemic period, there is a need for additional empirical research on its analysis and the interaction

of various impact mechanisms. This is because the more empirical study will provide evidence for policy enhancements to address and attain sustainability.

The theoretical section demonstrates that the primary theoretical underpinnings are founded on a market economy perspective, research in corporate finance, and the theory of information asymmetry, which can help us better introduce the study's primary issue. According to the market economy perspective, markets behave negatively when there are adverse external shocks, such as recessions, firm failures, and rising unemployment. However, according to research in corporate finance and information asymmetry theory, information asymmetry can significantly impact a firm's financing process, which is amplified when adverse external shocks exacerbate information asymmetry. Therefore, it is innovative and fair to examine the funding issues caused by the COVID-19 epidemic from the standpoint of knowledge asymmetry.

Following an analysis of the practise data, we have reached many findings through accurate data processing and analysis. The COVID-19 outbreak made it more difficult for companies to obtain financial services. By changing the measurement of the COVID-19 pandemic from the number of new cases to the cumulative number of confirmed cases and by replacing the financing constraint proxies (including the SA index, the WW index, and the FC index) to avoid chance results, the final results remained statistically significant.

In addition, the Section 4 contains a heterogeneity analysis, we discovered that the COVID-19 shock had distinct effects on various types of enterprises. The pandemic had a more significant impact on secondary industrial businesses (SIEs), nonstate-owned enterprises (non-SOEs), and small-scale enterprises (SSEs). In contrast, primary industry businesses (PIEs), tertiary industry enterprises (TIEs), state-owned companies (SOEs), and large-scale enterprises (LSEs) were less impacted by the pandemic, and their financing limitations increased only minimally.

In the final part, it is revealed why corporations may experience financial difficulties during a pandemic. Mechanistic study reveals that the COVID-19 epidemic impacts enterprises' capacity to acquire capital via commercial credit and debt costs. The justification is that CC is an essential route for enterprises' external financing, but DC is advantageous for firms' external financing. In conclusion, we present proof that the COVID-19 epidemic reduces businesses' financial costs and profitability.

Based on these pertinent papers and the findings of this research, several critical future directions are proposed. On the one hand, no country or region has as stringent COVID-19 preventive and control measures as China. On the other hand, China has a unique corporate structure, with the most significant number of state-owned firms (460,000) and the highest proportion of small and medium-sized enterprises (99%) worldwide. In light of these conditions, this paper's findings are also instructional and give research value for future company studies in China. Notably, the Chinese government may utilise SOEs' numerical and stability advantages to maintain general economic stability in the face of adverse external shocks. It can actively collaborate with non-SOEs to achieve a win-win situation. Nonetheless, the findings of this article indicate that small firms are more negatively affected by pandemic shocks. As 99.9% of SMEs are located in China, the Chinese government and SME management should seriously consider the epidemic and similar adverse external shocks.

Nowadays, the Chinese government made a major policy change in December 2022, namely a general relaxation of epidemic prevention and control policy efforts and a substantial easing of inter-regional and international movement restrictions. Therefore, future research might use the updated data to analyse the influence of the Chinese government's policy changes and enhance the study of the impact of COVID-19 on corporate finance. Shortly, the Chinese government will further liberalise epidemic limitations at import and export customs, which is a crucial direction for future study. This work can give essential support for this. The conclusions of this paper apply not just to China but also to other countries and places with harsh laws during epidemics. Even if there are regions with less

stringent policies than China, it is recommended that the study objectives be attained by changing the size of variables in the empirical analysis.

8. Conclusions

In order to ensure the quality of all the analyses in this work, our researchers used an article-combination technique and econometric principles, consulted a vast body of literature in the relevant field, and conducted several tests to ensure the reliability of the results. We ensured that each step was thoroughly cleansed and described in the investigation. Based on the analysis, this paper also examines the study's limitations and implications for practice.

This study has several limitations in terms of the chosen topic, research methodology, and data, which should be considered while discussing the conclusions. The publications included in the literature review were selected based on our criteria, which may need more consideration of other significant results and knowledge. For instance, the focus of the study was on corporate finance, but the outbreak was a global shock. Thus additional factors should be examined. To assure the quality of the articles, the literature for this study was obtained solely from Scopus, Springer, and China Knowledge Network; nonetheless, there may be publications of comparable existential significance that are not in these databases, which compromises the exhaustiveness of the literature review. However, these databases already contain the vast majority of the significant literature, and only a few papers of existential significance still need to be included. Therefore this constraint is acceptable with the results of this work. In addition, the epidemic variable in the research model is specified singularly, with only places with severe epidemics and areas with less severe epidemics. It does not account for the epidemic's severity or the intensity of local policies. Lastly, due to data restrictions, statistics are only accessible for the two years following the outbreak, making it impossible to analyse the epidemic's medium- and long-term effects.

In general, our conclusions have substantial consequences for actual economic progress. In terms of practical implications, the varied effect of COVID-19 on financing limitations implies that the effect of pandemics on various types of businesses is not consistent. Governments tasked with regulating economic development must actively steer and promote SIEs, non-SOEs, and SSEs to prevent a significant spread of financial risk. Similarly, other types of companies (such as PIEs, TIEs, SOEs, and LSEs) should use their capabilities and pursue sustainable growth in the framework of COVID-19 standardization.

In conjunction with the chapter on mechanisms analysis findings, it is evident that commercial credit is a significant source of financing for businesses and that the cost of corporate finance (DC) also influences the capacity of businesses to obtain capital. Government regulators, policymakers, and corporate managers should actively work to eliminate barriers to corporate finance, reduce the information asymmetry between companies and investors, and rationally regulate the cost of corporate finance so that companies can face the pandemic without difficulty.

Finally, the empirical study may also give auditors and investment advisors essential guidance regarding how adverse external shocks impact firms in corporate finance and company development and which types of firms are most affected. In sum, this study will be valuable to other academics and contribute to the field of study.

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Conflicts of Interest: All authors declare that no conflict of interest exists.

Appendix A

Appendix A.1. KZ Index

Specifically, we construct the KZ index as follows:

1. We have five variables from the Financial Statements: Net operating cash flow/Total assets in the last period ($\frac{CF_{it}}{A_{it-1}}$), Cash dividend/Total assets in the last period ($\frac{DIV_{it}}{A_{it-1}}$), Cash holdings/Total assets in the last period ($\frac{C_{it}}{A_{it-1}}$), Leverage (LEV_{it}) and Tobin's Q (Q_{it}). We find their median $\left(\frac{CF}{A}\right)_m$, $\left(\frac{DIV}{A}\right)_m$, $\left(\frac{C}{A}\right)_m$, $(LEV)_m$, and $(Q)_m$.

2. If $\frac{CF_{it}}{A_{it-1}} \leq \left(\frac{CF}{A}\right)_m$, then $kz_1 = 1$ or equal to 0; if $\frac{DIV_{it}}{A_{it-1}} \leq \left(\frac{DIV}{A}\right)_m$, then $kz_2 = 1$ or equal to 0; if $\frac{C_{it}}{A_{it-1}} \leq \left(\frac{C}{A}\right)_m$, then $kz_3 = 1$ or equal to 0; if $LEV_{it} \geq (LEV)_m$, then $kz_4 = 1$ or equal to 0; and if $Q_{it} \geq (Q_{it})_m$, then $kz_5 = 1$ or equal to 0.

3. Utilising Equation (A1), we can calculate *KZ*:

$$KZ = \sum_{i=1}^{5} kz_i \tag{A1}$$

4. Then, based on Equation (A2) With the method of ordered logistic regression, we use KZ as the dependent variable and $\frac{CF_{it}}{A_{it-1}}$, $\frac{DIV_{it}}{A_{it-1}}$, $\frac{C_{it}}{A_{it-1}}$, LEV_{it} and Q_{it} are independent variables, and we obtain the estimated coefficients of independent variables π_i.

$$KZ_{it} = \pi_0 + \pi_1 \frac{CF_{it}}{A_{it-1}} + \pi_2 \frac{DIV_{it}}{A_{it-1}} + \pi_3 \frac{C_{it}}{A_{it-1}} + \pi_4 LEV_{it} + \pi_5 Q_{it} + \varepsilon \tag{A2}$$

5. Finally, we put estimate coefficients π_i into Equation (A3) and calculate the KZ index that measures the financial constraints of each listed company. There are more financial constraints if the KZ index is larger.

$$KZindex_{it} = \pi_0 + \pi_1 \frac{CF_{it}}{A_{it-1}} + \pi_2 \frac{DIV_{it}}{A_{it-1}} + \pi_3 \frac{C_{it}}{A_{it-1}} + \pi_4 LEV_{it} + \pi_5 Q_{it} \tag{A3}$$

Appendix A.2. SA Index

We calculate the SA index according to the following model:

$$SAindex_{it} = -0.737 \times Size_{it} + 0.043 \times (Size_{it})^2 - 0.040 \times Age \tag{A4}$$

where *Size* is the logarithm of the total assets of the company and *Age* is the age of the company. Carefully, the total assets are in millions.

Appendix A.3. WW Index

Specifically, we can estimate the WW index by the following model:

$$WW_{it} = -0.091 \times CF_{it} + 0.062 \times DivPos_{it} + 0.021 \times Lev_{it} - 0.044 \times Size_{it} + 0.102 \times ISG_{it} - 0.035 \times SG_{it} \tag{A5}$$

where *CF* is cash flow to total assets; *DivPos* represents whether the company pays dividends, *DivPos* = 1 if the company pays dividends, or *DivPos* equals 0; *Lev* is Long-term liabilities to total assets; *Size* is the logarithm of the total assets; *ISG* is the average sales growth rate if the industry is owned by the company (according to the industry classifica-

tion standard of the China Securities Regulatory Commission in 2012, the manufacturing industry takes a two-digit code, and other industries take a one-digit code.); *SG* is the sales growth rate of the company.

Appendix A.4. FC Index

　　Normally, we construct the FC index as follows:

(1)　Sample data with missing data and data from financial industry companies were excluded. The continuous variables are abbreviated by 1% at both ends.

(2)　The three variables of company size, firm age, and cash dividend payout ratio were normalised using Equation (A7), and the mean values of the standardised variables were used to rank the listed firms in ascending order. The *QUFC* dummy variable was determined by utilising the upper and lower quartiles as the finance constraint cut-offs. Firms above the 66% quartile were characterised as having minimal financial constraints with *QUFC* = 0, while companies below the 33% quartile were described as having substantial financial constraints with *QUFC* = 1.

$$X = \frac{x_i - \frac{1}{n}\sum_0^n x_i}{\sqrt{\frac{1}{n-1}\sum_1^n \left(x_i - \frac{1}{n}\sum_0^n x_i\right)^2}} \tag{A6}$$

(3)　The *FC index* is then utilised in logit regressions, as shown in Equations (A7) and (A8), where Equation (A8) fits the probability of occurrence of the firm's financial constraints in each year, *P*, and defines it as the financing constraint variable FC index (which takes values between 0 and 1). The larger the FC index is, the more severe the firm's financing constraint.

$$P(QUFC = 1,0|Z_{it}) = \frac{e^{Z_{it}}}{1 + e^{Z_{it}}} + \varepsilon \tag{A7}$$

$$Z_{it} = \lambda_0 + \lambda_1 Size_{it} + \lambda_2 Lev_{it} + \lambda_3 \frac{CashDiv_{it}}{A_{it}} + \lambda_4 MB_{it} + \lambda_5 \frac{NWC_{it}}{A_{it}} + \lambda_6 \frac{EBIT_{it}}{A_{it}} \tag{A8}$$

　　where *Size* is the logarithm of total assets; *Lev* is leverage; *CashDiv* is cash dividend issue by company; *MB* is market-to-book ratio; *NWC* is net working capital; *EBIT* is earnings before interest and tax; and *A* is total assets.

Appendix A.5. Appendix A

Table A1. Additional descriptive statistics.

Variable	N	Mean	SD	Min	Max
KZ	28,408	0.990	2.449	−11.34	13.66
SA	28,408	−3.812	0.265	−5.646	−1.455
WW	24,238	−1.245	30.45	−4712	−0.574
FC	28,408	0.485	0.283	4.60×10^{-5}	0.987
NewCases	28,408	0.0661	0.249	0	1
SumCases	28,408	0.0769	0.266	0	1
Size	28,408	22.27	1.333	14.94	28.64
Growth	27,978	0.349	12.82	−2.733	1881
Lev	28,408	0.427	0.206	0.007	0.998
Fix	28,408	0.212	0.162	0	0.971
Roa	28,408	0.0351	0.0843	−3.994	0.786
Soe	28,274	0.366	0.482	0	1
Share	28,274	0.344	0.151	0.00290	0.900
TQ	28,408	2.152	5.038	0.641	715.9
CC	28,408	0.156	0.116	0	0.745
LC	28,408	0.00501	0.0556	−2.455	0.947

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