

Deleveraging, Debt Default Risk, and Enterprise Innovation: Evidence from China

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Abstract. This study, at the micro level, takes the Chinese central government's implementation of the "deleveraging" policy as a quasi natural experiment. Based on data from listed companies from 2013 to 2017, this study introduces the Metron default distance that balances financial indicators and asset value fluctuations to measure default risk. Therefore, the DID method is used to test the innovation situation of enterprises with high default risk under the "deleveraging" policy. Research has found that companies with significant default risks under policy shocks have significantly improved their innovation levels and increased their innovation achievements. Furthermore, this research studies the mechanism of the "deleveraging" policy on enterprise innovation from three perspectives: enterprise financing, investment, and business management. The implementation of the "deleveraging" policy will enhance the cash holdings and management governance level of enterprises with high default risk, thereby promoting enterprise innovation.

Keywords: Deleveraging; Default Risk; Enterprise Innovation.

1. Introduction

High leverage ratio is one of the important risk factors currently facing the Chinese economy, and the high leverage ratio of micro enterprises is the main reason for promoting the rise of macro leverage ratio [1]. How to control and reduce the leverage ratio of Chinese enterprises has become an urgent and significant task in achieving high-quality economic development in China. Since 2015, with the deployment of the Central Economic Working Conference, China has successively launched a series of "deleveraging" policies.

The report of the 20th National Congress of the Communist Party of China pointed out that "we must adhere to the principle that technology is the primary productive force, talent is the primary resource, and innovation is the primary driving force." Under the increasing pressure of the anti-globalization trend worldwide and the slowdown of domestic economic development, innovation is clearly an important focus to improve the quality of economic development. There are several things worth noting: (1) Can enterprises still carry out innovation and R&D activities normally under the "deleveraging" policy? (2) Are companies with higher risk default on its debts "struggling to survive" or "collapsing"? (3) In the implementation of the "deleveraging" policy, what mechanism will enterprises use to influence their own innovative development? These are the key focuses of this study.

Through the analysis of historical events, it can be seen that the relationship between enterprises with high default risks and innovation under external shocks is not absolutely negative. For example, during the 2008 financial crisis, the significant reduction in external demand and the superposition of technical trade barriers led to the closure of many export enterprises, but the surviving enterprises gained more market share and were forced to achieve industrial upgrading [2]. The increase in enterprise debt risk under the "deleveraging" policy suppresses enterprise innovation in the short term, but in the long run, it can force companies to innovate [3].

In the context of "deleveraging", the study of the relationship between enterprise debt default risk and enterprise innovation not only helps guide enterprises on how to effectively innovate when facing financial risks, and use innovation to form their own competitiveness to overcome difficulties, but

also helps government departments guide enterprises to improve their risk-taking level, and can help enterprises continue to innovate when systemic financial risks arise.

Based on this, this article takes listed companies in China as the research object and uses the double difference method to identify the impact of financing constraints represented by “deleveraging” policies on enterprise innovation. Research has found that after the implementation of the “deleveraging” policy, companies with higher default risks are more proactive in innovation compared to those with lower default risks, and their patent R&D achievements have significantly increased. Furthermore, the results of mechanism testing indicate that compared with enterprises with significant short-term debt and commercial credit default risks, the effect of deleveraging policies on promoting enterprise innovation is more significant for enterprises with higher long-term debt and bank loan default risks. After the implementation of the “deleveraging” policy, the management's governance ability and cash flow management of enterprises with high default risks have been significantly improved.

The main contribution of this article is that the Metron default distance, which combines financial indicators with asset value fluctuations, is used to measure the default risk of enterprises. Compared with using only financial indicators, it has a wider range of information sources and more timely risk assessment. This confirms that high default risk enterprises actively engage in innovation after the implementation of the “deleveraging” policy, and tests the specific path through which the “deleveraging” policy triggers innovation behavior in high default risk enterprises. This not only expands the research on the effectiveness of the “deleveraging” policy, but also enriches the relevant research on enterprise innovation.

The structure of this article is as follows: the second part is literature review, the third part is research design, the fourth part is empirical testing and analysis, the fifth part is further mechanism testing, and the sixth part is conclusion.

2. Literature Review

2.1. Policy Background and Default Risk Measurement

Since the entering of the 21st century, especially after the implementation of the “4 trillion” economic stimulus plan in 2008, the leverage level of Chinese enterprises has continued to rise rapidly. The leverage ratio of non-financial companies in China and the non-performing loan ratio of commercial banks have continued to rise since 2012, reaching 156.3% and 1.67% respectively by the end of 2015. The high leverage ratio, accompanied by an increase in non-performing loans, has reduced the ability of enterprises and banks to resist risks. At the end of 2015, the Central Economic Working Conference proposed the importance of “five priority tasks of cutting overcapacity, reducing excess housing inventory, deleveraging, lowering costs, and strengthening areas of weakness”, among which “deleveraging” requires “actively and prudently deleveraging, strengthening the financial leverage constraints of enterprises, especially state-owned enterprises, and gradually reducing enterprise liabilities to a reasonable level”, in order to achieve the policy goal of reducing long-term and systemic risks.

In terms of risk measurement methods, measuring the systemic risk borne by a single systemically important financial institution is still the mainstream method at present. However, this type of methods measure the risk in the post crisis diffusion stage and cannot reveal the source of financial risk in the micro mechanism of enterprises, lacking consideration of the financial risk faced by enterprises at the enterprise level. Nonetheless, high leverage ratio of enterprises often leads to debt defaults. At the micro level, debt defaults of enterprises are often a “crater” of financial risks, and can even lead to the outbreak of financial crises. Therefore, measuring the default risk of enterprises and building a risk transmission bridge between micro enterprises and macro financial risks is very important. Based on this, this study uses the risk of enterprise debt default to measure the risks faced by enterprises at the micro level.

The measurement methods for enterprise default risk mainly include financial indicator analysis, volatility methods, Metron default distance, KMV, and other financial risk measurement indicators. In the study of default risk, Beaver (1966) first used financial indicators to predict enterprise bankruptcy, while Altman (1968) proposed the Z-score model to measure the financial distress risk of a company. Subsequently, Ohlso (1980) and Zmijewski (1984) respectively used Logit and Probit models for financial distress prediction. However, some scholars believe that these financial models lack credibility because the financial statements reflect the company's past operating results and financial condition, which is easy to be manipulated. Using financial data alone will have certain limitations.

Then, scholars applied option pricing theory to predict enterprise default risk, not only relying on financial indicators, but also paying attention to the importance of asset value volatility, which provides important information about default probability (Metron, 1974). Through research, scholars confirmed that the Merton default distance model, which considers both financial indicators and asset volatility, does have important predictive power (Vassalou, 2004; Duffie, 2007). Chinese scholars have conducted extensive empirical research on the applicability of the Merton model to the Chinese market, confirming that the Metron default distance is applicable to the Chinese stock market and can effectively identify the default risk of enterprises (Kong, 2012).

2.2. Default Risk and Enterprise Innovation

Under the background of the "deleveraging" policy, the financing constraints of enterprises have been further strengthened. Whether enterprises that already have a high risk of default will be "impoverished" or "change when they are extremely poor" is still a controversial issue in academia. There is little discussion among domestic scholars on the relationship between default risk and enterprise innovation. Some studies suggest that deleveraging policies that strengthen enterprise financing constraints may have a negative impact on the innovation of companies with inherent high default risks. Zhang Jianshun (2021) found that an increase in the risk of local government debt will push up the borrowing costs of enterprises, bringing financing constraints to them, which will inhibit their innovative behavior (Amore, 2013). Due to policy restrictions on enterprise debt financing and tightening of credit policies, high-risk enterprises often face more difficult financing environments and higher financing costs. This makes it difficult for these enterprises to invest sufficient funds and manpower in R&D activities to enhance innovation under financial pressure.

However, some studies also suggest that the increased financing constraints caused by external shocks are not entirely negative for the innovation of enterprises with high default risk. Specifically, some enterprises with high default risk tend to reduce default risk by improving their technological innovation capabilities when facing difficulties, including improving products, optimizing production processes, exploring new markets, etc. Through technological innovation, enterprises can enhance their competitiveness and expand their sources of income so as to reduce financial risks and gain better development opportunities in fiercely competitive markets.

There is little discussion among domestic scholars on the relationship between default risk and enterprise innovation. Some studies suggest that financial risk shocks brought about by deleveraging policies may have a negative impact on the innovation of enterprises with high default risk. Due to policy restrictions on enterprise debt financing and tightening of credit policies, high-risk enterprises often face more difficult financing environments and find it difficult to carry out innovative activities. Giotopoulos (2022) explored the relationship between R&D, innovation, and productivity among manufacturing enterprises of different sizes in Greece during the debt crisis, and found that large enterprises had a higher willingness to invest in R&D during the crisis, which was positively correlated with innovation output. This indicates that financial risk, to some extent, promotes innovation in enterprises to overcome the crisis. Archibugi (2013) used Schumpeter's hypothesis of creative destruction and technological accumulation to compare the driving factors of innovation investment at different stages of the crisis. The study showed that existing companies were more likely to expand innovation investment before the crisis, while small businesses and new entrants

only expanded innovation related expenditures after the crisis. Fan (2020) found through selecting sample data from 10888 companies in 65 countries between 2003 and 2013 that companies with less market share, more employees, or more physical assets may enjoy higher R&D investment returns during economic crises.

Some studies have also found that deleveraging policies can encourage enterprises with high default risk to strengthen internal management and resource allocation, thereby improving innovation efficiency. Faced with the challenge of financing difficulties, enterprises need to be more cautious in choosing innovative projects and better utilize limited resources for research and development. This helps to improve the success rate and value of innovative projects, and reduce waste. Zouaghi (2018) used panel data from Spanish manufacturing companies from 2006 to 2013 to study the innovation behavior of companies during crises. The results showed that enhancing internal innovation capabilities and external knowledge assets can help alleviate the impact of financial crises. These studies suggest that there may be an interaction between financial risk and enterprise innovation. Feng Zhenghua (2018) found through studying the data of Chinese A-share listed companies from 2006 to 2016 that higher levels of innovation can effectively alleviate the risk of stock price collapse, and to some extent, alleviate the impact of default risk on the company.

In addition, some scholars believe that the relationship between financial risk and enterprise innovation is not unidirectional. Some studies have explored the innovation behavior of enterprises facing financial risk from factors such as financing constraints, investment decisions, and business management. Lome (2016) conducted binary logistic regression on a sample of 247 Norwegian manufacturers and found that companies that increased R&D investment in the later stages of the financial crisis performed significantly better than other companies, confirming that strengthening R&D investment during the crisis period is more important than during normal periods.

2.3. Comments on Existing Literature

For the research on financial risk and enterprise default risk, by reviewing relevant literature, we can learn that the academic community has conducted rich discussions on the sources and causes of financial risk, and it can be found that existing research mainly focuses on the systemic risks faced by the financial system or most financial institutions. There are also a large number of studies focusing on the behavior of enterprises in global financial crises, that is, focusing on a single risk event, but few scholars have taken the continuous and constantly changing debt default risk that enterprises face as the trigger for financial risks as their research object. In terms of measuring the default risk of enterprise debt, some scholars have paid attention to the importance of asset value fluctuations compared to relying solely on financial indicators,

In the research on financial risk and enterprise innovation, the academic community mainly focuses on the global financial crisis to examine the innovation behavior of enterprises when facing financial risks. It has been confirmed that factors such as R&D decisions, scale, and external environment of enterprises can lead to certain differences and uncertainties in the relationship between the two. The analysis perspective mainly reflects the response effects of different innovation inputs adopted by enterprises in different crisis stages. The conclusion is that improving innovation levels can help enterprises effectively cope with financial risks, such as increasing innovation input and output levels can effectively cope with stock price collapse risks in financial crises. The limitation of this is that few scholars have examined the impact of financial risk on the innovation input and output of enterprises.

In the discussion on how the assumption of financial risks by enterprises affects the innovation and development of enterprises, existing literature mainly discusses the following impact mechanisms: (1) The cost of funds mechanism, that is, financial risks impact the financing channels of enterprises, causing an increase in financing costs, thereby increasing the difficulty of financing for enterprises and affecting their innovation activities. (2) The investment decision-making mechanism, which refers to the fact that financial crises and risks will reduce the expected returns of enterprises by

reducing market demand, thereby affecting their investment decisions. Enterprises will pay more attention to cash holdings and investment channels. (3) The management mechanism. The risk of debt default will enhance the crisis awareness of enterprises, encourage them to change their business strategies, and force them to increase R&D investment and carry out innovative activities in order to overcome the crisis. Increasing their own R&D investment and knowledge assets can avoid the negative impact of financial risks on enterprises. This mechanism is particularly suitable for the actual response behavior of high-tech and large manufacturing enterprises during financial crises.

3. Research Design

3.1. Causal Identification Strategies and Regression Models

This article first examines the calculation of the default risk of a company at the micro level, and then uses the double difference method to link the default risk reflecting the company's fundamentals with the external deleveraging policy, transitioning from internal default risk to internal and external risk-taking ($Post \times Risk$). The idea can be drawn from the Capital Asset Pricing Model (CAPM): macroeconomic factors act on the expected return rate of a single security through risk-free returns, thereby achieving the connection between the micro level and macro level of the enterprise, and the DID method can be used to solve causal identification problems. With enterprise innovation and development as the dependent variable and financial risk as the explanatory variable, we plan to construct the following empirical model:

$$LnRD_{i,t} = \beta_0 + \beta_1 Post \times Risk_{i,t} + \beta_2 Control_{i,t} + FirmFE + Year \times Industry FE + \varepsilon_{i,t}$$

Among them, $LnRD$ represents enterprise innovation, $Post \times Risk$ represents enterprise risk-taking, and $Control$ represents control variables. $Firm FE$ represents individual fixed effects, while $Year \times Industry FE$ is further controlled as time industry fixed effects to exclude differences in the implementation of deleveraging policies across different industries and years.

3.2. Variable Definition

(1) Core dependent variable: Enterprise innovation

Innovation input and innovation output are the two main aspects of measuring a company's innovation in academia, and innovation output (number of patent applications) is widely regarded as the most direct and accurate indicator of measuring innovation (Yao, 2018). When a company applies for a patent, it indicates that its research and development behavior has achieved returns, while patent authorization and approval require a certain process, some even several years, and are also influenced by relevant policies, systems, and other factors. We select the number of enterprise patent applications as the main indicator to measure innovation level, and use the number of patent authorizations and research and development intensity as auxiliary indicators to measure innovation level for robustness testing. Considering the characteristic of delayed innovation output results, this study uses the number of patent authorizations granted by enterprises in the next year as the core dependent variable, and the logarithm is denoted as $LnRD$.

(2) Core explanatory variable: Enterprise risk-taking

At the micro level (within the enterprise), the expected default probability EDF, which measures the Metron default risk, is one of the mainstream methods for predicting financial distress in enterprises. Its significant predictive ability comes from its measurement of the direct and indirect effects of asset volatility on the occurrence of financial distress in enterprises (Cai, 2015). The formula is:

$$DD = \frac{\ln(V/F) + \left(\mu - \frac{1}{2}\sigma_V^2\right)T}{\sigma_V\sqrt{T}}$$

Among them, DD is the default distance of Merton, V is the value of the company's assets, F is the book value of the company's liabilities, μ is the expected return on assets, σ_V is the volatility of the company's asset value, T is the expiration time of the company's debt, and according to common practice, the expiration time (T) of the debt is set to 1 year. The corresponding EDF is:

$$EDF = N(-DD)$$

Where $N(\cdot)$ represents the cumulative probability of the standard normal distribution.

At the macro level (external to the enterprise), due to the influence of the company's fundamentals, Risk may not be independent of other independent variables. In order to ensure that the relationship between variables is a causal relationship, and to consider that external macro environmental factors can also have a significant impact on default risk, this article chooses the deleveraging policy of 2015 as the research background, because the sudden implementation of this policy has led to all enterprises facing bank loan defaults at the same time, resulting in a sudden increase in default risk for enterprises. To avoid the overlapping impact of other events (such as the 2018 Sino-US trade war) caused by a long research window, we plan to choose two years before and after 2015, namely 2013-2017, as the research period, and set the annual dummy variable $Time$. Before 2015, this variable takes a value of 0, and after that, it takes a value of 1. We incorporate $Post$ into the concurrent transaction multiplier $Time \times Risk$ to alleviate endogeneity issues by using double difference.

By further sorting of the Merton default distance (DD) of each company, we can obtain the median, with those below the median facing greater risk compared to the overall sample (the smaller the default distance, the greater the risk), defined as 1, and vice versa as 0. Risk is set as the DID interaction term.

(3) Control variables

Table 1. The descriptive statistical results

Variable symbols	Variable definition	Observation value	Average value	Standard deviation	Minimum value	Maximum value
<i>lnRD</i>	The core dependent variable is the natural logarithm of the number of patent authorizations granted by the enterprise in the next year	7,212	2.373	1.456	-0.693	8.397
<i>Time</i>	The dummy variable of the "deleveraging" policy is set to 1 for 2015 and after, and 0 vice versa	8,883	0.603	0.489	0	1
<i>Risk</i>	The dummy variable of default risk, with default distance less than the median taken as 1, and vice versa taken as 0	8,883	0.473	0.499	0	1
<i>Time × Risk</i>	Core explanatory variable, the interaction term of the above two	8,883	0.382	0.486	0	1
<i>lnAge</i>	Age of the enterprise, natural logarithm of the years since establishment of the enterprise	8,818	2.113	0.734	0	3.296
<i>ROA</i>	Return on asset, the ratio of net profit to total assets	8,883	0.0352	0.0645	-2.834	0.482
<i>Growth</i>	Total asset growth rate, the ratio of the difference between total assets at the end of this period and total assets at the end of the previous period to total assets at the end of the previous period	8,883	0.215	0.914	-0.707	45.46
<i>Q</i>	Tobin's Q value, market value/(total assets - net intangible assets - net goodwill)	8,863	3.082	2.543	-3.819	46.36
<i>FixedAssets</i>	Fixed asset ratio=fixed assets/total assets	8,883	0.225	0.158	0	0.948
<i>lnmanager</i>	The total number of senior management personnel disclosed in the annual report	8,879	1.818	0.369	0	3.178

The age of the enterprise is measured by the natural logarithm of the number of years since its listing. Profitability is measured by the return on asset (ROA) of the enterprise. Enterprise growth is measured by the growth rate of total assets of the enterprise. Enterprise value is measured by Tobin's q value. Fixed asset ratio is measured by the ratio of fixed assets to total assets. The number of senior executives is measured by the natural logarithm of the number of directors, supervisors, and senior executives. The descriptive statistical results are shown in the table below.

3.3. Data Sources and Sample Selection

The sample period for the variables selected in this article is from 2013 to 2017, and the data is sourced from the CSMAR Economic and Financial Research Database, CCER Economic and Financial Database, and Wind Database.

Drawing on the research of other scholars and the focus of this study, the data was screened using the following methods: excluding companies with ST and ST * during the sample period. The financial structure of the financial and insurance industry is unique and does not belong to the real economy, therefore we exclude listed companies in the financial and insurance category. We also exclude companies with abnormal financial data, and sample of companies retained must meet the following requirements: total assets greater than 0, total assets greater than fixed assets, total assets greater than intangible assets, total assets greater than current assets, total liabilities greater than 0, total liabilities greater than long-term liabilities, total liabilities greater than current liabilities, and total assets greater than total liabilities. To reduce the impact of sample outliers on the research results, this study applies a 1% Winsorize truncation to the patent and financial data of all listed companies.

4. Empirical Results and Analysis

4.1. Benchmark Regression Results and Interpretation

In order to examine the changes in innovation among enterprises with high default risk after the implementation of the "deleveraging" policy, the empirical results are shown in the table below. After controlling for individual fixed effects and industry \times year fixed effects of enterprises, the estimated coefficients of $Post \times Risk$ are significantly positive. The second column further controls for the enterprise characteristic variable, and the estimated values of this coefficient are still significantly positive. These results indicate that after the implementation of the "deleveraging" policy, compared with enterprises with lower default risk, enterprises with higher default risk have significantly improved their innovation output. The possible reason for this is that for enterprises with high default risks, their debt pressure is relatively high, and traditional financing channels are limited. However, it also forces these enterprises to pay more attention to their core competitiveness and innovation capabilities. Enterprises with high default risks, when facing financial difficulties and credit pressure, usually take various measures to improve innovation output in order to avoid default.

Table 2. The empirical results

Variables	(1) $LnRD_{i,t}$	(2) $LnRD_{i,t}$
$Post \times Risk_{i,t}$	0.1008***	0.996***
$Control_{i,t}$	No	Yes
Enterprise fixed effect	Yes	Yes
Industry \times Time fixed effect	Yes	Yes
N	6938	6901
R^2	0.7245	0.7250

4.2. Robustness Test

In order to ensure the robustness of the empirical results, we conducted empirical tests on the replacement of proxy variables, parallel trend hypothesis, and the method of dividing treatment and control groups.

4.2.1. Replacing Proxy Variables

This section tests whether the “deleveraging” policy has an impact on enterprise innovation by replacing the proxy variables of default risk and enterprise innovation. In terms of remeasuring the dependent variable, we replace the proxy variable for enterprise innovation mentioned earlier, change the measurement angle, and measure enterprise innovation investment by taking the natural logarithm $\ln RDI$ of enterprise R&D expenditure, and then use the double difference method to test the results.

In terms of recalculating the independent variables, the measurement indicator of Risk in this article has been changed from the default distance calculated based on the traditional Metron default distance to the default distance simplified by Bharath (2008), using the median as the critical data value. For enterprises with default distances higher than the median, the Risk KMV/Bharath in the interaction term will be assigned a value of 0. Those below the median are considered to be at risk of financial crisis or bankruptcy, and will be assigned a value of 1, and are substituted into the interaction term for the test.

The results of replacing proxy variables are shown in the table below. The empirical results are basically consistent with the previous results, which proves the robustness of the double difference experimental results in this paper.

Table 3. The results of replacing proxy variables

Variables	(1) $\ln RDI_{i,t}$	(2) $\ln RDI_{i,t}$ - KMV	(3) $\ln RDI_{i,t}$ - Bharath
$Post \times Risk_{i,t}$	0.1391***	0.0878***	0.1175***
$Control_{i,t}$	Yes	Yes	Yes
Enterprise fixed effect	Yes	Yes	Yes
Industry \times Time fixed effect	Yes	Yes	Yes
N	7952	6901	6901
R^2	0.882	0.7248	0.7252

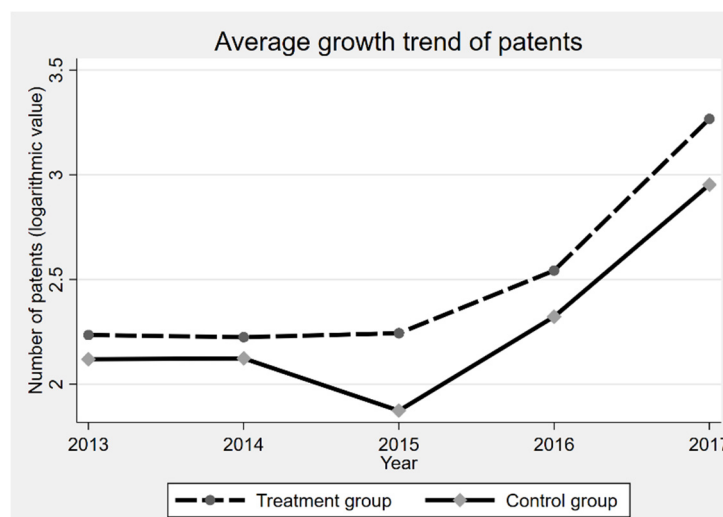


Fig 1. The important presuppositions of DID method were tested

For the sake of reliability in the research results of this article, it is necessary to test the important premise assumption of the DID method, which must meet the parallel trend assumption, that is, before the occurrence of exogenous policies, the dependent variables (LnRD) corresponding to the treatment group and the control group should develop according to parallel trends. As shown in the figure below, after the implementation of the "deleveraging" policy in 2015, the innovation output of enterprises with higher default risk (treatment group) showed a higher degree of growth compared to enterprises with lower default risk (control group), and before 2015, the two had a relatively consistent trend of change.

In addition, this study still needs to concern about whether the changes in the trends of the treatment group and the control group are influenced by factors ignored or unobservable in the model. Therefore, we must use placebo tests to determine whether the estimation results of the double difference method are robust. In order to further test whether the results of this article are driven and influenced by these unobservable factors, this study adopts the approach of Zhou (2018) to conduct a placebo test, which randomly allocates the impact of the "deleveraging" policy on specific enterprises (enterprises with high debt default risk) and repeats this random process 1000 times. This random processing ensures that the impact of random allocation ($Post \times Risk$) does not affect the corresponding number of patents (LnRD). In this case, the figure below shows the t-value distribution of the core explanatory variable $Post \times Risk$ estimated in 1000 treatments. It can be found that most of the t-values are concentrated near 0, which is significantly different from the t-value (0.0324) in the benchmark regression mentioned earlier. Based on this, it can be inferred that unobservable factors do not have an undeniable impact on the estimation results. The previous estimation results in this paper are robust.

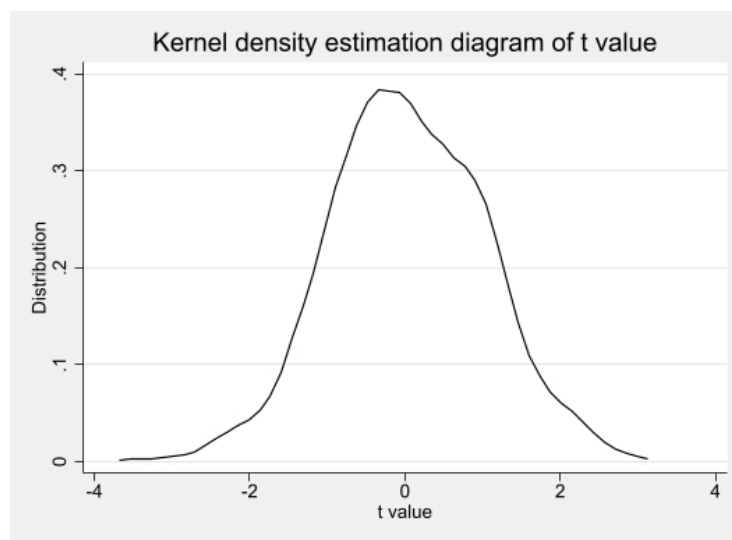


Fig 2. The distribution of T-values estimated by the core explanatory variable $Post \times Risk$ over 1000 treatments

4.3. Analysis of Impact Mechanisms

Based on literature review and benchmark regression results, this study intends to examine the corresponding mechanisms of how enterprise risk-taking affects innovation and development from three aspects: financing, cash management, and operational management.

(1) Financing cost mechanism: debt sources and debt maturities

We conduct group research based on long-term debt ratio and short-term debt ratio according to the maturity of liabilities. From columns (1) and (2), it can be seen that both empirical results are positively significant. Compared with the short-term debt ratio, the long-term debt ratio has a more positive promoting effect on enterprise innovation. The possible reason for this is that the borrowing amount of short-term liabilities is relatively small, the financing speed is fast, but the time period for

repayment of principal and interest is short. However, the borrowing amount of long-term borrowings is large, and the repayment period is long, which can be used more for innovative activities with high investment, long cycle, and high risk, providing strong financial support, and thus more conducive to the increase of innovative output.

Table 4. The regression results were studied in groups

Variables	(1) $LnRD_{i,t}$ - Longdebit	(2) $LnRD_{i,t}$ - Shortdebit	(3) $LnRD_{i,t}$ - Bank	(4) $LnRD_{i,t}$ - Company
$Post \times Risk_{i,t}$	0.6372***	0.2000**	0.2943*	0.0705
$Control_{i,t}$	Yes	Yes	Yes	Yes
Enterprise fixed effect	Yes	Yes	Yes	Yes
Industry * Time fixed effect	Yes	Yes	Yes	Yes
N	6618	6901	5891	5891
R2	0.7259	0.7249	0.7350	0.7348

Further analysis is conducted by grouping the bank lending rate and commercial credit rate based on the source of liabilities. According to the regression results of columns (3) and (4), it can be seen that bank lending has a significant positive impact on enterprise innovation, while commercial credit has no significant impact on innovation. The possible explanation is that companies often explain the purpose to banks when applying for loans, and banks adopt effective constraints and supervision on the use of loan funds. Loans for R&D investment can often be implemented, while commercial credit amounts are relatively small and mostly exist in the form of inventory, thus having a limited impact on enterprise innovation.

(2) Investment decision-making mechanism: operating cash and cash holdings

Due to preventive needs, companies will reduce their investments when facing significant risks and instead hold a large amount of cash to cope with future external investment opportunities and smooth their own R&D investments. Adequate cash holdings help companies maintain stability in their research and development investments (Yang, 2014). Under the "deleveraging" policy, companies may actively hold cash or maintain good operating cash flow when facing external financing constraints, providing internal funding sources for their innovative activities (Pu, 2016). This article reflects this investment decision-making mechanism by examining the cash holdings and net operating cash flows of the enterprise after the sum of monetary funds, net short-term investments, trading financial assets, and operating financial assets. A model can be constructed:

$$Cash_{i,t} = \beta_0 + \beta_1 Post \times Risk_{i,t} + \beta_2 Control_{i,t} + FirmFE + Year \times Industry FE + \varepsilon_{i,t}$$

Among them, $Cash_{i,t}$ is the investment decision variable, measured by cash holdings $Cash1$ and net operating cash flows $Cash2$, while other variables are consistent with the previous text. The regression results are shown in columns (1) and (2), indicating a significant increase in cash holdings and operating cash flows of high default risk enterprises under policy shocks. This indicates that when facing default risk, companies will increase their cash holdings to cope with research and development innovation, thereby confirming that under the "deleveraging" policy, high default risk companies can reduce investment and increase cash flow through investment decision-making mechanisms, thereby promoting innovation.

(3) Business management mechanism

The level of internal business management is often considered to be positively correlated with enterprise innovation (Bertrand, 2003; Yang, 2019). Under external shocks, the increase in default risk may prompt enterprises to improve their management capabilities, leading to an increase in

internal "source opening and cost saving". Enterprises may continuously open up resources and reduce redundancy through improving operational efficiency. This management mechanism is reflected by examining the per capita profit of the company (i.e. the logarithm of the ratio of net profit to the number of employees) and the excess employee rate (Liao, 2014).

If the per capita profit level and excess employee rate of high default risk enterprises have undergone significant changes after the implementation of the "deleveraging" policy, it indicates that the company can influence its innovative behavior through business management, and a model can be constructed:

$$Management_{i,t} = \beta_0 + \beta_1 Post \times Risk_{i,t} + \beta_2 Control_{i,t} + FirmFE + Year \times Industry FE + \varepsilon_{i,t}$$

Among them, $Management_{i,t}$ is the variable of business management ability, measured by per capita profit $Management1$ and excess employee rate $Management2$, while other variables are the same as above. The regression results of columns (3) and (4) show that the regression coefficient of the interaction term is significantly positive in terms of per capita profit and significantly negative in terms of excess employee rate, indicating that "opening up resources and reducing costs" has been achieved, confirming that the management mechanism of high default risk enterprises under the "deleveraging" policy has been affected.

Table 5. Regression result

Variables	(1) <i>Cash1</i>	(2) <i>Cash2</i>	(3) <i>Management1_{i,t}</i>	(4) <i>Management2_{i,t}</i>
Post x Risk	0.1105***	0.0917**	0.0650***	-0.0562**
Controls	Yes	Yes	Yes	Yes
Enterprise fixed effect	Yes	Yes	Yes	Yes
Industry * Time fixed effect	Yes	Yes	Yes	Yes
N	7472	5799	6915	7468
R2	0.8750	0.7403	0.8304	0.8550

4.4. Heterogeneity Analysis

The previous analysis focused on the overall level, which may overlook the results bias caused by differences in the characteristics of enterprises themselves. This section divides the selected research sample into more detailed heterogeneity analysis, in order to provide more targeted empirical evidence.

(1) Nature of enterprise ownership

Different ownership of enterprises may lead to differences in the impact of enterprise risk-taking on innovation. This study divides and regresses on the basis of whether the enterprise is state-owned.

The regression results of columns (1) and (2) show that the coefficient of non-state-owned enterprises is significantly positive, while the coefficient of state-owned enterprises is small and not significant. This may be because state-owned enterprises with government support have more abundant resources to avoid debt defaults. Therefore, the "deleveraging" policy has a relatively weak impact on the innovation activities of state-owned enterprises, while non-state-owned enterprises with higher debt default risks may have more crisis awareness and be more proactive in improving their competitiveness through innovation.

(2) Region where the enterprise is located

China has a vast territory, and there are significant differences in the level of economic development, business environment, and industrial structure among different regions, which will also have different

impacts on enterprise innovation. Therefore, this article analyzes the main characteristics of the regions where the enterprises are located, combined with the geographical location data of listed companies in the Guotai'an CSMAR database and the division of China's regions in the China Statistical Yearbook. The regions of sample enterprises are divided into three categories: eastern region, central region, and western region. Then, the benchmark model mentioned earlier is used to conduct group DID regression on them.

Table 6. The benchmark model mentioned earlier is used to conduct group DID regression on them

Variables	(1) State owned enterprises	(2) Non state-owned enterprises	(3) Eastern region enterprises	(4) Central region enterprises	(5) Enterprises in Western Regions
Post×Risk	0.0042	0.0952***	0.0926***	-0.0349	0.0700
Controls	Yes	Yes	Yes	Yes	Yes
Enterprise fixed effect	Yes	Yes	Yes	Yes	Yes
Industry * Time fixed effect	Yes	Yes	Yes	Yes	Yes
N	3348	5535	6227	1009	1334
R2	0.7246	0.7249	0.7250	0.7246	0.7246

The regression results of columns (3), (4), and (5) show that the coefficient of enterprises in the eastern region is significantly positive at the level of 1%, while the coefficient in the central and western regions is not significant, indicating that under the impact of deleveraging policies, enterprises with high default risk in the eastern region have significantly increased their R&D output. The coefficient in the central region is negative, and compared to listed companies in the eastern and western regions, the innovation of listed companies in the central region is relatively insufficient. This indicates that there are differences in regional innovation among companies with higher default risks at the regional level, and companies in the eastern region can still persist in innovation and achieve remarkable results under the impact of the "deleveraging" policy.

(3) Enterprise scale

Table 7. The regression results

Variables	(1) Small businesses	(2)Medium sized enterprises	(3) Large enterprises
$Post \times Risk_{i,t}$	0.1436*	-0.0128	0.0732
$Control_{i,t}$	Yes	Yes	Yes
Enterprise fixed effect	Yes	Yes	Yes
Industry x Time fixed effect	Yes	Yes	Yes
N	1990	2098	2224
R ²	0.4974	0.6767	0.8196

The division of enterprise size is based on the third percentile of the logarithmic value of total assets. Enterprises with a logarithmic value of total assets above the second third percentile are classified as large enterprises, enterprises below the first third percentile are classified as small enterprises, and the remaining portion is classified as medium-sized enterprises.

The regression results in the table below show that there is a significant difference in the significance of large, medium, and small enterprises. Compared to large and medium-sized enterprises, the coefficient of small enterprises is significantly positive at the level of 1%, indicating that small

enterprises with higher default risk have significantly increased their innovation under the impact of the "deleveraging" policy. This may be because small enterprises usually have limited funds and pay more attention to talent and technology innovation, making them easier to adjust and change.

5. Conclusion and Policy Suggestions

The policy of "deleveraging" has become an important institutional guarantee for China to achieve stable economic growth and prevent and resolve financial risks. This study takes the 2015 "deleveraging" policy as a quasi natural experiment and uses the double difference method to examine its impact on enterprise innovation. The following research conclusions have been drawn: (1) The "deleveraging" policy significantly enhances the innovation level of enterprises with high debt default risk. (2) This policy has a more significant effect on promoting innovation for enterprises with higher default risks in long-term debt and bank loans. (3) This policy can play a role in promoting enterprise innovation by enhancing cash flow holdings and enhancing the governance level of management. (4) Through heterogeneity analysis, the policy is proved to have a more significant promoting effect on innovation in non-state-owned enterprises, enterprises in the eastern region, and small enterprises.

Based on the above conclusions, the implications obtained in this study are as follows:

- (1) The Chinese government can support enterprises in their innovation activities by providing loan facilities, R&D subsidy policies, and other means when they face significant default risks. The government can also strengthen supervision and guidance, promote enterprises to enhance their risk-taking ability and actively carry out innovation, in order to prevent and resolve systemic financial risks at the micro level.
- (2) The government and enterprises should strengthen their risk management and evaluation capabilities, including monitoring and early warning mechanisms for enterprise debt default risks, so as to better understand the risk situation faced by enterprises, detect risks early, issue early warnings, and take corresponding prevention measures.
- (3) When facing the risk of debt default, enterprises should dare to innovate rather than just sit idly by and give up their R&D activities. Meanwhile, it is necessary to strengthen enterprise governance capabilities, strengthen internal controls, improve transparency and financial disclosure levels, increase the trust of investors and creditors, and seek more stable and sustainable methods for innovation.

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