**Local governments’** **enterprise-helping** **relief policies for equity pledges and** **corporate innovation: Evidence from Chinese private listed companies**

**Abstract:**

Equity pledges, as a financing agreement, can cause financial risk while expanding the financing channels of listed companies. Compared to state-owned enterprises, private companies often face higher equity pledge risks due to financing difficulties. Several local governments in China implemented relief policies to alleviate the equity pledge risks of private companies in 2018. Relief policy relieves private firms from the pressure of funds for innovation and increases the level of risk-taking, which can have a positive effect on firms' innovation. However, current research has not focused on this point. Therefore, we use the panel data of private listed companies from 2014-2021 and construct a difference-in-difference model to empirically analyze the impact of this relief policy implemented by local governments on corporate innovation. This paper finds that the relief policies for equity pledges significantly promote corporate innovation, and the conclusions remain robust after a series of robustness tests and endogeneity discussions. The mechanism test finds that relief policies promote corporate innovation by increasing R&D investment and improving the enterprise's risk-taking capacity. The degree of financing constraints plays a positive role in the relief policy's promotion of firms' innovation. Further research finds that the relief policy is more effective in promoting corporate innovation for private listed companies in competitive industries and with poorer disclosure quality. These findings indicate that the relief policies are pragmatic practices for local governments in China to fulfill their fiscal functions, which can provide a practical reference for alleviating enterprises' financing constraints and stimulating their innovation vitality.

**Keywords:** Equity pledge, Relief policy, Innovation

**Introduction**

As a financing agreement, equity pledges have expanded the financing channels for companies and major shareholders. Equity pledge financing has grown rapidly in China in the last ten years. According to the Wind database, as of June 30, 2018, the number of pledged companies was 3433, with the proportion of pledges exceeding 50% as high as 772 companies. In particular, the pledge rate of private enterprises is significantly higher than that of state-owned enterprises. 60% of the state-owned enterprises have a pledge rate of less than 1%, compared to 12.8% of the private enterprises. However, equity pledges could expose the company to the risk of liquidity shortage and an unintended risk of losing control rights if the pledged shares have to be liquidated. As of June 30, more than 80% of the private companies with equity pledges have not yet reached the release date. 402 private listed companies' pledged stocks have hit the close-out line, with a market value of 477 billion yuan, accounting for 10% of the total market value of all private companies' unreleased shares. In China, controlling shareholders' equity pledges can increase the separation of control and cash flow (Pang and Wang, 2020), the expropriation of minority shareholders' interests through "Tunneling" behavior (Xu, 2021), and the risk of share price collapse (Li et al., 2022). Controlling shareholders' equity pledges can reduce companies' risk-taking (Ni et al., 2022). Private listed companies tend to face more severe equity pledge risks and liquidity difficulties due to their low political affiliation and greater dependence on the market (Shi et al., 2023; Su et al., 2019). In the face of widespread equity pledge risks, some local governments of China implemented a series of relief policies for equity pledges (hereafter called Relief Policies) in 2018 to alleviate the listed companies' financing risk by replenishing their equity capitals or reducing their debts. By the end of 2018, local governments had implemented relief policies in 21 of the 33 provinces in mainland China. Following the implementation of the relief policy, the equity pledge rate of listed companies in China has been effectively reduced, from 9.75% at the end of 2018 to 4.87% at the end of 2021.

The relief policy mainly helps listed companies with equity pledge risks to tide over their difficulties through debt, direct equity investment, equity participation in the establishment of sub-funds, transfer of loans and subsidies, risk compensation, and loan interest subsidies. As disclosed in provincial policy papers, it provides necessary financial relief to specific private enterprises that are in line with the direction of optimization and upgrading of economic structure, and have development prospects but encounter difficulties temporarily. The relief policy is essentially a special type of government subsidy, and its specificity is reflected in three aspects: Firstly, the relief policy is a short-term emergency relief policy, and the government introduces the relief policy to alleviate the temporary difficulties of private enterprises and relieve their short-term liquidity. Secondly, the relief policy has obvious preferences and tendencies for the policy targets, focusing on supporting industrial leaders, strategic emerging industries, and enterprises with good prospects in line with the optimization and transformation of economic structure. Finally, the relief policy operates in a market-oriented manner, with the government taking the lead and social capital jointly participating in the formation of a relief fund, which is managed by a professional fund management organization.

Improving the innovation capacity of enterprises is an important way to improve their production and operation and enhance their competitiveness in the market. Innovation activities not only require a large amount of investment but also require companies to have a good level of risk-taking. Previous studies have found that companies with equity pledges have poor risk-taking ability, which constrains their innovation investment (Wang et al., 2020) and reduces their willingness to innovate (Pang and Wang, 2020). Therefore, relief policies carried out by local governments are theoretically helpful to companies' innovation. Relief policies can provide stable and large amounts of funds for companies, which can encourage management to increase R&D investment and thus obtain more innovation output. Moreover, relief policies can reduce the risk of equity pledges, alleviate the agency problem caused by equity pledges (Xu, 2021), weaken the preference of controlling shareholders for low-risk investment activities, and increase the willingness to invest in high-risk innovation activities (Qin and Wang, 2023). Previous studies have focused on the impact of government support policies e.g., tax incentives (Song et al., 2020), intellectual property protection (Allred and Park, 2007), and government subsidies (Carboni, 2011) on corporate innovation. However, existing studies lack empirical evidence on the impact of local government relief policies on listed companies' innovation. Therefore, based on the empirical evidence of private listed companies in China, this paper investigates whether local governments' enterprise-helping relief policies can promote innovation in listed companies and the impact mechanisms.

The main work of this paper includes the following three aspects: first, based on the existing literature and combined with the institutional background of the relief policy, this paper proposes testable research hypotheses to provide a basis for the subsequent empirical analysis of how the relief policy affects corporate innovation. Secondly, a suitable econometric model is established. The risk of equity pledges of listed companies varies greatly from province to province, and the relief policy intensity varies from province to province, so it is difficult for the common discrete double-difference model to reflect the accurate policy effect. This paper utilizes the relief policy as an exogenous shock to the change in the equity pledge rate of listed companies, and at the same time takes into account the regional differences in the above exogenous shock, measures the relief strength by the interaction term between the mean value of the equity pledge rate of listed companies in each province before the implementation of the relief program and whether the relief policy is implemented or not in each province, and constructs the strength double-difference model to conduct empirical analyses. Thirdly, the robustness test is carried out. This paper centers on the empirical analysis of the impact of relief policy on corporate innovation and its mechanism. It enhances the credibility of the empirical results by transforming the core variables, switching to individual fixed effects, changing the clustering method, carrying out Propensity Score Matching, Heckman's two-stage method, Placebo test, and Parallel Trend Test.

The contribution of this paper is as follows: First, previous studies have focused on the effects of direct government subsidies (Lin and Luan, 2020; Xu et al., 2021), but less on relief policies. This paper finds that the relief policy, as a short-term policy, can not only provide short-term relief in alleviating firms' equity pledge risks but also promote long-term activities such as firms' innovation, which is a long-cycle and time-consuming activity, thus expanding the economic consequences of the relief policy. Second, numerous studies(e.g., Wang et al., 2020; Pang and Wang, 2020) have shown that an increase in the rate of equity pledges inhibits firms from engaging in innovative activities. However, few studies have focused on whether a reduction in the equity pledge rate can promote corporate innovation. In this paper, we find that the relief policies carried out by provinces to alleviate the risk of equity pledges can significantly promote corporate innovation, which indirectly indicates that the reduction of the equity pledge rate can motivate enterprises to carry out innovative activities and enrich the research on the factors influencing corporate innovation. Third, at present, the majority of enterprises are facing financing constraints and liquidity difficulties, this paper provides a new perspective to alleviate the problem of enterprises' financing constraints and stimulate the vigor of enterprise innovation. Currently, how to help enterprise relief policy be more effective has attracted much attention, so this paper's research on the impact of relief policy on corporate innovation of listed companies can be used as a reference for governments at all levels to help local governments scientifically formulate and implement relevant policies.

**Institutional background and research hypotheses**

*Institutional background*

In China, to alleviate the pressure on capital, many listed companies adopt equity pledges to raise funds. Before 2014, the development of China's equity pledge market was relatively slow, with commercial banks and trust companies as the main providers. In late 2013, the Shanghai Stock Exchange (SSE) and China Securities Depository and Clearing Corporation Limited (CSDC) jointly issued the *Measures on Equity Pledge and Repo Transactions and Registration and Clearing*, which provided institutional safeguards for the development of over-the-counter stock pledge repurchase operations. Since 2014, the development of the equity pledge market has accelerated, with securities companies replacing commercial banks and trust companies as the main pledge holders. Compared with bank loans, equity pledge financing does not require regulatory approval and does not affect shareholders' control and voting rights, making it a relatively convenient financing method for listed companies.

The rate of equity pledges of listed companies in China has remained high in recent years, and in particular, the scale of controlling shareholders' equity pledges has continued to expand. According to the Wind database, as of the end of 2018, more than 95% of China's listed companies were involved in equity pledge business, and the market value of the pledged stocks amounted to 4. 23 trillion yuan, accounting for about 10% of the total market value. However, there are risks associated with equity pledge financing. According to the provisions of the *Guarantee Law of the People's Republic of China*, when the equity pledge expires, if the pledgee is unable to repay the pledged amount due to the pledgee's own insufficient solvency, the pledgee has the right to sell the pledged shares, and any shortfall in the sale price will be settled by the pledgee. Moreover, even if the pledge period has not yet expired, when the value of the pledged goods decreases (i.e., the share price falls), the pledgee has the right to request the pledgee to provide additional security; once the share price continues to fall, resulting in the inability of the pledgee to provide additional security, the pledgee may sell the pledged shares in advance. A large number of studies have shown that controlling shareholders' equity pledges can have the effect of decreasing investment efficiency (Hao and Lixia, 2023a), decreasing R&D investment and innovation efficiency (Peiyuan and Li, 2019; Ren et al., 2022), increasing the risk of stock price collapse (Guo and Xu, 2023; Li et al. Wang, 2020), decreases risk-taking capacity (Cai, 2019), affects firm financing (Guo and Xu, 2023; Hu et al., 2024), and influences firm performance (Cai, 2019).

The above problems have attracted widespread attention from governments at all levels and are more serious among private listed companies (Hao and Lixia, 2023b; Shi et al., 2023).In 2018, under the guidance of the central government, provincial governments have independently carried out a series of relief policies to alleviate the equity pledge risks of private listed companies. Through the formation of relief funds of varying sizes, provincial governments have used market-based and law-based approaches to give priority to helping private listed enterprises in the province that are operating well in their main business, in line with the direction of optimization and upgrading of the economic structure, and that have temporarily fallen into liquidity difficulties as a result of market fluctuations to alleviate their financing difficulties and risk of equity pledges.

The relief policy is essentially a government subsidy, in which the local government provides financing assistance to the rescued enterprises. However, unlike general government subsidies, relief policies have the following characteristics: First, general government subsidies have a longer cycle, and the government continuously guides and supports the long-term development of the industry through subsidy policies. A large number of studies have shown that the purpose of government subsidies focuses on guiding industrial development in the long term, for example, Lin and Zhang(2023) and Yang et al.(2019) showed that government subsidies promote renewable energy investment and guide the development of new energy industries through monetary subsidies and tax incentives. Others have shown that government subsidies stimulate technological innovations(Shefer and Frenkel, 2005) and lead to a green transition(Liu et al., 2020) through long-period subsidies. Similarly, Andreoni and Bergstrom(1996) also found that the most important social goal of government subsidies is to supply public goods of large scale and high investment, public goods with slow returns. However, the relief policy targets enterprises that are temporarily in liquidity difficulties, aims to alleviate companies’ short-term equity pledge risks, and plays a short-term relief role. Second, the relief policy focuses on key private enterprises such as industry leaders, strategic emerging industries, and high-growth enterprises, while general government subsidies do not have a clear preference for the target of subsidies. For example, the Hubei Provincial Government stated that "the 10 billion yuan relief fund set up by the province will, through market-oriented and law-based methods, give priority to helping private listed enterprises in the province that are operating well in their main business, in line with the direction of optimization and upgrading of the economic structure, and that have temporarily fallen into liquidity difficulties due to market fluctuations." Third, the relief policy is operated in a market-oriented manner, and the relief fund is formed with the participation of social capital. Multiple market players jointly contribute to the establishment of the relief fund through equal consultation, and the investment and operation are handled by a professional fund management organization.

*Relief policy and corporate innovation*

We argue that relief policies can promote innovation in private enterprises. On the one hand, relief policy can provide more innovation resources for enterprises, so that enterprises can have enough innovation resources to increase investment in R&D. Compared to state-owned enterprises, private enterprises have a low degree of political relevance, their property rights are more vulnerable to arbitrary infringement by the government and officials, and the business risks of the enterprises are higher, which in turn increases the risk for banks to give them a loan, thus making it more difficult for these private enterprises to obtain bank loans(Bai et al., 2006). Local governments carry out relief policies to provide stable and large amounts of capital to enterprises through the establishment of relief funds to alleviate the financing constraints faced by enterprises so that they can obtain lower-cost financing, and thus have sufficient cash flow and resources of technological resources to invest in innovation (Silva and Carreira, 2012). With the same efficiency, firms that increase their investment in R&D will receive more innovative output (Yu et al., 2016).On the other hand, relief policy can increase firms' risk-taking capacity and their willingness and preference to innovate. Private listed companies tend to face more severe equity pledge risks and liquidity difficulties due to their low political affiliation and greater dependence on the market (Shi et al., 2023; Su et al., 2019). Wei and Wang(1997) found that Chinese state-owned banks tend to lend to state-owned firms and that private firms face higher costs of external finance. When the relief capital enters the enterprise, it essentially represents that multiple market players such as the government bear the risk together with the enterprise, and the risk borne by the enterprise itself is decentralized (Lai et al., 2015), and the willingness to bear the innovation risk becomes higher. Relief policy can reduce a series of risks brought by equity pledges to enterprises (Li et al., 2019) alleviate the agency problem that equity pledges bring (Xu, 2021), weaken the management's preference for low-risk investment activities, and increase the willingness to invest in high-risk innovation activities (Qin and Wang, 2023). Moreover, according to the signaling theory, if the government announces a series of policies to help enterprises with temporary difficulties, receiving these government subsidies has crowding-in effects on corporate endogenous financing, debt financing, and equity financing, which will reduce financing costs and compensate for indirect loss caused by knowledge spillover in the process of R&D activities (Xu et al., 2020). Based on the above analysis, we propose the following research hypotheses:

**Hypothesis 1.** Relief policies have a promoting effect on corporate innovation in private companies.

*Relief policy, risk-taking capacity, and corporate innovation*

It has been shown that firms' risk-taking ability is an important factor affecting corporate innovation (Fernandes and Paunov, 2015; Hoecht and Trott, 2006; Li et al., 2022). Specifically, the higher the risk-taking level of a firm, the stronger its willingness to innovate and the more it invests in innovation accordingly; on the contrary, if the risk-taking level of a firm is lower, the lower its willingness to engage in innovation as a high-risk activity, and the less it invests in innovation (Caggese, 2012). Innovation involves high risk, and the risks inherent in R&D are always present in the long investment process from idea to actual commercialization (Hoecht and Trott, 2006). Firms' involvement in innovation activities increases their own risk of uncertainty, including the risk of R&D failure and the risk of imitation and plagiarism of their innovations (Li et al., 2022). The level of enterprise risk-taking not only depends on the management's behavioral willingness, but also has a great relationship with the amount of enterprise resources, and engaging in high-risk activities will inevitably require the guarantee of enterprise resources such as capital and technology.

High risk-taking ability can help to raise more funds for the enterprise and provide financial security for innovative activities. In addition, the managerial self-confidence that comes with high risk-taking ability will drive firms to expand their innovative activities (Latham and Braun, 2009). As the level of risk-taking increases, the firm's tolerance for innovation failures will also increase, which can stimulate innovation activities in the firm.

Private companies face higher external financing costs and their cash flow and liquidity risks are greater. They are more vulnerable to arbitrary infringement by the government or officials due to their low political relevance (Shi et al., 2023; Su et al., 2019; Bai et al., 2006). When facing an uncertain environment, they are unable to obtain timely assistance, as is the way with state-owned enterprises, and have a higher risk of control transfer(Bai et al., 2006). The relief policy can improve the risk-taking ability of private companies. From the perspective of policy purpose, the relief policy aims to alleviate a series of risks such as stock price collapse (Li et al., 2022) and control transfer (Zhi-Bin and Shi-Yu, 2015) brought by equity pledge to enterprises, which can improve the risk-bearing ability of enterprises to a certain extent. From the perspective of policy effect, relief policy provides enterprises with lower-cost capital supply through a market-oriented way, optimizes the resource allocation of enterprises, and can improve the ability of enterprises to bear risks. In addition, once an enterprise receives a series of support from the relief fund through the relief policy, it means that the enterprise's innovation project has been recognized and supported by the government and multiple market players, and the enterprise's innovation risk is shared by the enterprise and multiple market players such as the government, so that the risks and pressures faced by the enterprise can be dispersed (Hoecht and Trott, 2006). At the same time, the government's recognition and support of an enterprise's R&D project indicates that the enterprise's R&D capability is trustworthy, and the fact that the enterprise's innovation project is regulated by the government can make the management more confident in engaging in risky innovation activities (Latham and Braun, 2009), and the willingness to take risks will be enhanced. Based on the above analysis, we propose the following research hypotheses:

**Hypothesis 2.** Relief policies promote corporate innovation by increasing the risk-taking capacity of companies.

*Relief policy, R&D investment, and corporate innovation*

Relief policy can encourage private enterprises to increase investment in innovation activities. On the one hand, the relief policy guides financial resources to flow into enterprises, provides sufficient financial support, reduces the pressure on private enterprises’ cash flow, weakens the defensive cash-holding incentives of enterprises (Chou et al., 2021), and then weakens the liquidity holding needs of managers, reduces the financial elasticity of enterprises, expands the immediate investment activities, and shifts the willingness of enterprises to innovate upward. On the other hand, relief policy can reduce the risk of equity pledges, alleviate the second type of agency problem caused by equity pledges, weaken the preference of controlling shareholders for low-risk investment activities, and increase their willingness to invest in high-risk innovation activities (Hoegl et al., 2008; Xu et al., 2021). In addition, when multiple market players such as the government share the innovation risk with enterprises, enterprise management is more confident to carry out innovation activities and increase investment in innovation activities.

A substantial number of literature (Lai et al., 2015; Yan and Renyong, 2013) has shown that increasing firms' R&D inputs is an important means to promote firms' innovation output. Based on the input-output theory, the more R&D inputs, the more innovative outputs of firms, with the same efficiency. Companies can generate new knowledge, fostering discoveries and increasing their chances of developing patented inventions through R&D (Somaya et al,2007). Nooteboom et al. (2007) found a positive correlation between R&D investment intensity and innovation output for 116 firms in the chemical, automotive, and pharmaceutical industries. Shefer and Frenkel(2005) also propose that R&D expenditures constitute the most influential variable in a firm’s ability to

innovate. Xu et al.(2020) empirically analyzed the relationship between government subsidies, R&D investment, and innovation performance pharmaceutical sector in China, and found that R&D investment has a positive impact on innovation performance. Also, the findings of Zhu et al.(2019)showed that R&D investment and R&D personnel investment have a significant positive impact on firms' technological innovation performance in China's high-tech industries. Based on the above analysis, we propose the following research hypotheses:

**Hypothesis 3.** The relief policy promotes corporate innovation by increasing firms' investment in research and development (R&D).

*Relief policy, financing constraints, and corporate innovation*

Under the condition of information asymmetry, to avoid moral hazard and adverse selection, banks will draw a red line on the creditworthiness and repayment ability of the enterprises receiving loans, and only those enterprises that meet the standard will be eligible for loans. Private enterprises often have unclear accounts and lack qualified collateral, making it difficult for them to meet the banks' creditworthiness requirements for loanees(Hope et al., 2011). A large number of studies (Beladi et al., 2021; Ding et al., 2022; Hyytinen and Toivanen, 2005; Poncet et al., 2010) have shown that firms' resources for innovation are limited by financing constraints and that the higher the degree of financing constraints of firms, the lower the level of firms' investment in innovation. Firms need to invest a large amount of capital on a long-term and continuous basis to carry out innovation projects, and once firms are short of capital due to insufficient financing, their innovation projects will have to be suspended or even terminated (Poncet et al., 2010). The high uncertainty of the outputs of innovation activities implies information asymmetry in the innovation process and induces potential moral hazard, which makes innovation activities face serious external financing constraints (Beladi et al., 2021; Ding et al., 2022). On the one hand, to avoid competitors prying into business secrets, firms are reluctant to disclose information about R&D and innovation, and external investors face serious information asymmetry. Due to the non-exclusivity of knowledge and the prevention of information leakage (Bond and Meghir, 1994), R&D activities are generally not disclosed as trade secrets, so it is difficult for external investors to obtain R&D-related information and identify the merits of the investment projects, the risk premium demanded by investors is high, and the cost of external financing for the enterprises increases (Silva and Carreira, 2012), and the enterprises do not have sufficient long-term financing to support corporate innovation. On the other hand, investors' adverse selection behavior exacerbates the financing constraints faced by firms, making it more difficult for them to obtain funding, which in turn leads to firms having to cut back on or even abandon their investment in innovation (Hoegl et al., 2008; Silva and Carreira, 2012).

For companies with a high degree of financing constraints, relief policies can provide timely assistance to alleviate the underinvestment of enterprises due to financing constraints. On the one hand, similar to government subsidies, the relief policy is carried out by the government with multiple market players through the establishment of the relief fund, which can provide lower-cost financing channels for enterprises facing financing constraints and enhance the liquidity of their cash flow. The relief policy adopts the market-oriented operation of "equity+debt", and its specific modes of operation include borrowing, transferring shares to increase capital, and transferring the right of control, etc., thereby meeting the various financing needs of enterprises. In addition, different from general government subsidies, the relief policy adopts market-oriented operation, which can effectively alleviate the rent-seeking behavior of enterprises and reduce the crowding out of their innovation resources. On the other hand, the relief fund has a double authentication signal for enterprises-technical authentication and regulatory authentication, which can greatly reduce the information asymmetry between enterprises and investors (Xu et al., 2021). In terms of signaling theory, if an enterprise obtains the relief fund, it indicates that the enterprise's R&D project has been recognized and supported by the government and market players (Yu et al., 2016), and the enterprise's R&D capability is trustworthy. Therefore, the relief policy can release a guiding signal to the external capital market and attract all kinds of elements to gather, to optimize the enterprise's resource allocation, and provide financing reserves for innovative projects. For companies with lower financing constraints, they can obtain sufficient low-cost and liquid financing and have a wide range of financing channels, so these companies with lower financing constraints rely less on the relief policy, and the relief policy has almost no effect on their corporate innovation. Based on the above analysis, we propose the following research hypotheses:

**Hypothesis 4.** Relief policy is more effective in promoting firm innovation when the degree of financing constraints is higher.

**Data and Model**

*Data*

Since the Shanghai Stock Exchange (SSE) and China Securities Depository and Clearing Corporation Limited (CSDC) jointly issued the *Measures on Equity Pledge and Repo Transactions and Registration and Clearing* in 2013, equity pledges of listed companies in China have experienced rapid development from the following year. Therefore, this paper explores the impact of the relief policy on corporate innovation using panel data of Chinese listed companies from 2014 to 2021. Firm-related financial data and corporate governance data are obtained from the China Stock Market & Accounting Research Database (CSMAR). The number of firms' patent applications is obtained from the China Research Data Service Platform (CNRDS). After obtaining the initial sample, we conducted several regular data screenings, including excluding companies in the finance and insurance industries, companies with special treatment (ST or ST\*), and companies with missing data. Continuous variables have been winsorized above 99% and below 1%. All regressions are clustered at the firm level for standard errors.

*Variable description*

**Dependent variable:** The dependent variable of this paper is corporate innovation ($Innovation\_{i,j,t}$), where i denotes the enterprise, j denotes the province where the enterprise is located, and t denotes the year. Considering that invention patents can better reflect the nature of innovation than utility model patents and design patents, this paper takes the natural logarithm of the total number of invention patents independently filed by the company in the year after adding 1 to measure the innovation of the enterprise.

**Independent variable:** The independent variable in this paper is the intensity of relief. By the end of 2018, local governments in 21 provinces in China responded to carry out relief policies, while 12 provinces did not. To avoid the possible endogeneity problem of the independent variable, this paper refers to the related literature (Lu and Yu, 2015) and uses an interaction term(*Pledge2018,j·Policyj,t*)to measure the implementation intensity of the relief policy. Where *Pledge 2018,j* denotes the average equity pledge rate of listed firms in each province before the implementation of the relief policy (i.e., at the end of the third quarter of 2018), and *Policyj,t* is a dummy variable for whether or not the provinces have implemented the relief policy. The above interaction term implies that the higher the equity pledge rate of controlling shareholders of listed companies in a province before the implementation of the relief policy, the higher the risk of liquidity distress and transfer of control brought by equity pledges, and the stronger the relief efforts of local governments. We try to collect the size of the relief fund in some provinces (the size of the relief fund in a small number of provinces is not publicly disclosed) and find that there is a significant positive correlation between the intensity of relief policy and the size of the relief fund, which further confirms that the measurement of the relief intensity is reasonable.

**Mechanism variables:** We argue that relief policies promote firm innovation by increasing firms' risk-taking capacity and increasing firms' R&D investment. Firms' risk-taking ability is measured as the rolling standard deviation of the industry-adjusted ROA. R&D investment is measured by the total amount of a firm's R&D investment in the year as a percentage of its operating revenue. A firm's financial resources greatly influence its propensity to engage in innovative activities. R&D activities require substantial capital resources, and R&D investment will increase when a firm has sufficient assets. On the other hand, a firm's risk-taking ability reflects its willingness to innovate, and the relief policy promotes innovation by increasing the firm's ability to bear innovation risks. In addition, when the degree of financing constraints of enterprises is higher, the relief policy promotes enterprise innovation more obviously. In this paper, we use the KZ index to measure the degree of financing constraints of enterprises and construct the cross-multiplier term between the KZ index and relief policy through the KZ index grouping to examine the influence of financing constraints in the relief policy to promote corporate innovation.

**Control variables:** Referring to the existing literature (Hyytinen and Toivanen, 2005; Xu et al., 2021), this paper also controls for the following variables that may affect firm innovation. Specifically: natural logarithm of the firm's assets(*Size*).,natural logarithm of firm duration (*Age*), natural logarithm of the number of board members(*Board)*, return on assets (*ROA*), leverage ratios (*LEV*), shareholding proportion of top ten shareholders (*Top10*), independent director proportion (*INDEP*). To verify that the growth of corporate innovation is brought about by the relief policy rather than other government subsidy policies, this paper controls for the government subsidies received by firms (*Grant*), measured as the natural logarithm of the government subsidies received by firms in the current year after adding 1. In addition, given the different levels of economic development of provinces, this paper also controls for the level of provincial innovation (*RI*) and the level of provincial financial development (*RF*), which reflect regional characteristics, and are measured by the natural logarithm of the number of invention patent applications received in the province and the ratio of the total amount of all deposits and loans of the financial institutions in the province compared to the GDP, respectively. Descriptive statistics of the variables involved in this paper are shown in **Table 1**.

**Table 1**

Descriptive statistics for variables.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Obs | Mean | Std. dev. | Min | Median | Max |
| *Innovation* | 7,877 | 2.115 | 1.370 | 0 | 2.079 | 5.313 |
| *Policy* | 7,877 | 0.444 | 0.497 | 0 | 0 | 1 |
| *Pledge* | 7,877 | 2.322 | 0.453 | 1.364 | 2.144 | 4.061 |
| *Size* | 7,877 | 21.97 | 1.018 | 19.39 | 21.87 | 25.20 |
| *Age* | 7,877 | 1.621 | 0.881 | 0 | 1.609 | 3.219 |
| *Board* | 7,877 | 2.082 | 0.182 | 1.609 | 2.197 | 2.639 |
| *LEV* | 7,877 | 0.361 | 0.175 | 0.0530 | 0.347 | 0.874 |
| *ROA* | 7,877 | 0.0517 | 0.0654 | -1.575 | 0.0481 | 0.542 |
| *Top10* | 7,877 | 0.590 | 0.142 | 0.226 | 0.601 | 0.975 |
| *INDEP* | 7,877 | 0.379 | 0.0529 | 0.143 | 0.364 | 0.571 |
| *Grant* | 7,877 | 15.29 | 2.145 | 8.854 | 15.62 | 19.37 |
| *RF* | 7,877 | 3.866 | 1.470 | 1.754 | 3.719 | 8.131 |
| *RI* | 7,877 | 11.17 | 1.041 | 4.522 | 11.44 | 12.40 |

*Model*

In order to avoid endogeneity problems as much as possible and to verify the impact of relief policy on corporate innovation, this paper constructs a basic regression model:

$Innovation\_{i,j,t}=α\_{0}+α\_{1}Pledge\_{j,2018}×Policy\_{j,t}+\sum\_{}^{}α\_{k}CV\_{i,j,t}+v\_{i}+u\_{t}+ε\_{i,j,t}$ (1)

where *Innovationi,t* represents firm innovation, *pledge2018,j·policyj,t* represents relief intensity, and its coefficient α1 reflects the extent to which the relief policy affects firm innovation. CVi,t denotes the control variables. α0 is a constant term, vi is a province dummy variable, ut is a dummy time variable, and εi,t is a random error term. This paper controls for time and province fixed effects.

**Regression analysis**

*Baseline regression analysis*

The regression results show that the regression coefficient of relief policy on corporate innovation is significantly positive at 1% confidence interval (see **Table 2**). This shows that the relief policy can significantly promote corporate innovation. For every 1 percentage point increase in the average controlling shareholder pledge rate in a province before the implementation of the relief policy, the number of invention patents filed by listed companies after the implementation of the relief policy increases by 0.171 percentage points.

**Table 2**

Baseline regression results.

|  |  |  |  |
| --- | --- | --- | --- |
|  | (1) | (2) | (3) |
| Variable | *Innovation* | *Innovation* | *Innovation* |
| *Pledge×Policy* | 0.099\*\*\* | 0.091\*\*\* | 0.171\*\*\* |
| (6.26) | (5.26) | (3.08) |
| *Size* |  | 0.500\*\*\* | 0.498\*\*\* |
|  | (12.96) | (12.65) |
| *Age* |  | -0.174\*\*\* | -0.171\*\*\* |
|  | (-5.14) | (-5.08) |
| *Board* |  | 0.051 | 0.020 |
|  | (0.27) | (0.11) |
| *LEV* |  | -0.085 | -0.081 |
|  | (-0.50) | (-0.48) |
| *ROA* |  | 1.268\*\* | 1.177\*\* |
|  | (2.54) | (2.38) |
| *Top10* |  | -1.214\*\*\* | -1.189\*\*\* |
|  | (-5.53) | (-5.43) |
| *INDEP* |  | -0.070 | -0.266 |
|  | (-0.11) | (-0.44) |
| *Grant* |  | 0.061\*\*\* | 0.065\*\*\* |
|  | (5.74) | (5.55) |
| *RI* |  | 0.182\*\*\* | 0.348\*\*\* |
|  | (6.91) | (3.87) |
| *RF* |  | -0.040\*\* | 0.093 |
|  | (-2.10) | (1.39) |
| Constant | 2.023\*\*\* | -10.896\*\*\* | -13.241\*\*\* |
| (60.24) | (-11.07) | (-9.40) |
| Control Variables | NO | YES | YES |
| Region FE | NO | NO | YES |
| Year FE | NO | NO | YES |
| N | 7,877 | 7,877 | 7,877 |
| R2 | 0.007 | 0.155 | 0.172 |

Note: Numbers in parentheses are t-statistics. \*\*\*, \*\*, or \* represent 1%, 5%, or 10% significance levels, respectively.

*Robustness checks*

To verify the robustness of the results, this paper conducts robustness tests in the following aspects:

First, replace the independent variables and dependent variables. To begin with, this paper switches to a discrete difference-in-difference model, ignores the differences in the intensity of relief policy implementation across provinces, and replaces the independent variable with *Policyj,t*(a dummy variable for whether provinces implement relief policy or not). As shown in **Table 3**, the coefficient of Policy is significantly positive after replacing the independent variable. Similarly, this paper changes the measure of corporate innovation to the natural logarithm of the sum of the number of invention patents and utility model patents independently filed by the enterprise in the year after adding one. After replacing the dependent variable, the coefficient of Pledge×Policy is still significantly positive, indicating that the findings of this paper are relatively robust.

**Table 3**

Robustness checks by replacing variables.

|  |  |  |
| --- | --- | --- |
|  | (1) | (2) |
|  | *Innovation* | *Innovation* |
| *Policy* | 0.608\*\*\* |  |
| (3.30) |  |
| *Pledge×Policy* |  | 0.144\*\*(2.31) |
| *Size* | 0.476\*\*\* | 0.457\*\*\* |
| (12.86) | (11.16) |
| *Age* | -0.167\*\*\* | -0.148\*\*\* |
| (-5.10) | (-4.06) |
| *Board* | 0.015 | -0.130 |
| (0.08) | (-0.64) |
| *LEV* | -0.143 | 0.436\*\* |
| (-0.87) | (2.39) |
| *ROA* | 0.064\*\*\* | 0.052\*\*\* |
| (5.58) | (4.05) |
| *Top10* | -0.308 | -0.980 |
| (-0.53) | (-1.50) |
| *INDEP* | 0.683\*\* | 0.732\*\* |
| (2.24) | (2.15) |
| *Grant* | -1.148\*\*\* | -0.852\*\*\* |
| (-5.39) | (-3.70) |
| *RI* | 0.274\*\*\* | 0.243\*\*\* |
| (3.10) | (2.59) |
| *RF* | 0.125\* | 0.153\*\* |
| (1.94) | (2.22) |
| Constant | -12.098\*\*\* | -10.197\*\*\* |
| (-8.94) | (-6.96) |
| Year FE | YES | YES |
| Region FE | YES | YES |
| N | 7,877 | 7,877 |
| R2 | 0.165 | 0.167 |

Note: Numbers in parentheses are t-statistics. \*\*\*, \*\*, or \* represent 1%, 5%, or 10% significance levels, respectively.

Second, Propensity Score Matching (PSM). When local governments implement relief policies for enterprises in their provinces, the differences in the relief intensity implemented are affected by provincial characteristics such as the level of economic development. At the same time, the relief policy focuses on helping firms with good operation in their main business, in line with the direction of optimization and upgrading of economic structure, and in temporary liquidity difficulties due to market fluctuations to relieve the risk of equity pledges, thus these firms may have a higher probability of obtaining relief assistance. Therefore, the sample in this paper may suffer from self-selection bias. To mitigate the endogeneity problem caused by sample selection, this paper uses the sample after propensity score matching for regression. Specifically, this paper uses 1:1 sampling to match the samples(samples before 2018 are yearly matching, and the sample after 2018 is matched as a whole) with propensity scores based on firm size, firm age, board size, gearing ratio, ROA, equity restriction ratio, independent director proportion, government subsidies, provincial innovation level, provincial level of financial development, and the industry in which the firm is located, as well as whether or not the firm is a hi-tech enterprise. After matching and regression, the coefficient of Pledge×Policy is significantly positive at 5% confidence level, which fully explains the role of the relief policy in promoting innovation in listed enterprises, and the regression results are shown in **Table 4**.

Third, the Heckman two-stage method. In the regression analysis of the initial research sample, some provinces received stronger relief policies, but there are still some provinces that did not carry out relatively strong relief policies. Due to the influence of many subjective and objective factors, the selected samples often lead to bias in the assessment results. To correct the sample selection bias, this paper uses the Heckman two-stage model to validate it. In the first stage, a dummy variable is first constructed based on whether the relief intensity of the province in which the sample enterprises are located is greater than the median (1 if greater than the median), and it is used as an explanatory variable. Then, the Inverse Mills Ratio (IMR) is calculated using the Probit model. In the second stage, to test for selection bias, the IMR was added to the control variables before regression, and the test results are shown in Table 4. After adding IMR, the coefficient of Pledge × Policy is still significantly positive at the 5% level, indicating that the findings of the main regression are still robust after correcting the sample selection bias problem.

**Table 4**

**Robustness checks using the Heckman model and Propensity Matching method.**

|  |  |  |
| --- | --- | --- |
|  | Heckman | PSM |
|  | *Innovation* | *Innovation* |
| *Pledge×Policy* | 0.204\*\*\* | 0.175\*\*\* |
| (3.27) | (2.73) |
| *Size* | 0.539\*\*\* | 0.481\*\*\* |
| (4.44) | (12.79) |
| *Age* | -0.210\*\* | -0.186\*\*\* |
| (-2.47) | (-5.41) |
| *Board* | 0.023 | 0.018 |
| (0.12) | (0.10) |
| *LEV* | -0.178 | -0.184 |
| (-1.00) | (-1.10) |
| *ROA* | 0.076\*\*\* | 0.067\*\*\* |
| (3.19) | (5.58) |
| *Top10* | -0.575 | -0.302 |
| (-0.78) | (-0.51) |
| *INDEP* | 0.851\* | 0.639\*\* |
| (1.91) | (2.06) |
| *Grant* | -1.471\*\* | -1.182\*\*\* |
| (-2.35) | (-5.44) |
| *RI* | 0.329\*\*\* | 0.385\*\*\* |
| (3.04) | (4.02) |
| *RF* | 0.089 | 0.092 |
| (1.34) | (1.35) |
| Imr | 0.982 |  |
|  | (0.58) |  |
| Constant | -13.981\*\*\* | -13.215\*\*\* |
| (-3.87) | (-9.28) |
| Year FE | YES | YES |
| Region FE | YES | YES |
| N | 7,877 | 7,632 |
| R2 | 0.165 | 0.165 |

Note: Numbers in parentheses are t-statistics. \*\*\*, \*\*, or \* represent 1%, 5%, or 10% significance levels, respectively.

Fourth, switching to firm fixed effects. To control for unobservable non-time-varying variables at the individual level, this paper re-controls for firm and time fixed effects to verify the robustness of the findings. The regression results after controlling for firm and time fixed effects are shown in column (1) of **Table 5**, and the coefficient of Pledge × Policy is still significantly positive, indicating that the conclusions of this paper are robust.

Fifth, changing the clustering method. To verify the robustness of the research conclusions, this paper clusters standard errors of the basic regression at the province level. After changing the clustering method, the regression coefficient of Pledge×Policy is still significantly positive, and the regression results are shown in column (2) of **Table 5**, indicating that the conclusions of the main regression are still robust.

Sixth,

**Table 5**

**Other robustness checks.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | (1) | (2) | (3) |
|  | *Innovation* | *Innovation* | *Innovation* |
| *Pledge×Policy* | 0.092\* | 0.187\*\*\* | 0.144\*\* |
| (1.86) | (4.64) | (2.47) |
| *Size* | 0.445\*\*\* | 0.475\*\*\* | 0.429\*\*\* |
| (7.99) | (12.14) | (10.89) |
| *Age* | -0.000 | -0.167\*\*\* | -0.136\*\*\* |
| (-0.01) | (-2.92) | (-3.70) |
| *Board* | 0.320\*\* | 0.015 | -0.036 |
| (2.03) | (0.09) | (-0.18) |
| *LEV* | -0.123 | -0.136 | -0.038 |
| (-0.77) | (-0.70) | (-0.22) |
| *ROA* | 0.005 | 0.064\*\*\* | 0.108\*\*\* |
| (0.57) | (4.49) | (8.21) |
| *Top10* | 0.405 | -0.316 | -0.492 |
| (0.93) | (-0.71) | (-0.77) |
| *INDEP* | -0.189 | 0.676\* | 0.695\*\* |
| (-1.03) | (2.03) | (2.07) |
| *Grant* | -0.487\*\* | -1.146\*\*\* | -1.029\*\*\* |
| (-2.03) | (-3.47) | (-4.52) |
| *RI* | 0.242\*\*\* | 0.296\*\*\* | 0.319\*\*\* |
| (3.38) | (3.20) | (3.30) |
| *RF* | -0.002 | 0.098 | 0.012 |
| (-0.04) | (1.30) | (0.17) |
| Constant | -10.999\*\*\* | -12.142\*\*\* | -11.644\*\*\* |
| (-7.65) | (-10.25) | (-7.96) |
| Year FE | YES | YES | YES |
| Region FE | YES | YES | YES |
| N | 7,433 | 7,877 | 6,298 |
| R2 | 0.733 | 0.165 | 0.172 |

Note: Numbers in parentheses are t-statistics. \*\*\*, \*\*, or \* represent 1%, 5%, or 10% significance levels, respectively.

Seventh, we perform the Placebo Test to verify that the enhancement of corporate innovation is promoted by the relief policy rather than other unobserved factors. We randomly selected the experimental group for the Placebo Test and repeated random sampling 500 times. As shown in **Figure 1**, the estimated coefficients of the test are all basically centered around the value of 0, and the vast majority of regressions are insignificant, which are all different from the true coefficients, which indicates that the finding of this paper is relatively robust.

**Figure 1**

**Placebo test.**



Eighth, the Parallel Trend Test. The difference-in-difference model requires the treatment and control groups to satisfy the parallel trend assumption to ensure the unbiasedness of the estimates. In the baseline model of this paper, the parallel trend assumption means that before the implementation of the relief policy, the invention patent applications of enterprises in the provinces that carry out the relief policy and those in the provinces that do not carry out the relief policy are consistent in terms of a time trend. After the implementation of the relief policy, the break of the parallel trend in the treatment and control groups indicates that the innovation of enterprises in the provinces with the relief policy has changed relative to that of enterprises in the provinces without the relief policy. The results of the parallel trend test are shown in **Figure 2**, which satisfies the above assumptions and indicates that the difference-in-difference model constructed in this paper is valid.

**Figure 2**

**Parallel Trend test.**



*Analysis of transmission mechanism*

We argue in this paper that risk-taking ability is an important transmission mechanism for the relief policy to promote corporate innovation. To test hypothesis H2, this paper uses the standard deviation of the industry-adjusted ROA of the sample companies to measure the risk-taking level of enterprises and constructs the following model (2):

$Risktaking\_{i,j,t}=β\_{0}+β\_{1}Pledge\_{j,2018}×Policy\_{j,t}+\sum\_{}^{}β\_{k}CV\_{i,j,t}+v\_{i}+u\_{t}+ε\_{i,j,t}$ (2)

The regression results of the model are shown in column (1) of **Table 6**, and the coefficient of Pledge×Policy is -0.004 and significant at 5% level, which indicates that the relief policy significantly reduces the risk of enterprises and improves their risk-taking ability. This suggests that the relief policy, through improving the ability of firms to bear innovation risks, increases the willingness of firms to undertake innovative activities, which in turn promotes firms' innovation.

Similarly, in order to test hypothesis H3, this paper constructs model (3) to explore the mechanism role of R&D investment on relief policy to promote corporate innovation:

$RD\_{i,j,t}=γ\_{0}+γ\_{1}Pledge\_{j,2018}×Policy\_{j,t}+\sum\_{}^{}γ\_{k}CV\_{i,j,t}+v\_{i}+u\_{t}+ε\_{i,j,t}$ (3)

The regression results of the model are shown in column (2) of **Table 6**, and the coefficient of Pledge × Policy is 0.421 at 5% confidence level, which indicates that after the relief policy occurs, firms are helped and financially supported by the relief policy, thus increasing R&D investment. This suggests that the relief policy greatly promotes R&D investment, provides sufficient financial support for firms, reduces the pressure on firms' cash flow, and weakens firms' defensive cash holding motives (Chou et al., 2021), which in turn weakens managers' liquidity holding demand, and shifts firms' willingness to innovate upward.

To test H4, this paper constructs model (4) to verify the moderating effect of the level of financing constraints on the relief policy to promote corporate innovation, in which KZ is a dummy variable constructed based on the median of the KZ index of the sample firms, and KZ takes the value of 1 for samples with a KZ index greater than the median, otherwise, it is 0. If the coefficient of Pledge × Policy is significantly positive, it means that when the intensity of relief policy by the local government is greater, the financing constraints of firms are eased and firms have more economic resources to carry out innovative activities. Model (4) is as follows:

$Innovation\_{i,j,t}=δ\_{0}+δ\_{1}Pledge\_{j,2018}×Policy\_{j,t}×KZ+δ\_{2}Pledge\_{j,2018}×Policy\_{j,t}+δ\_{3}KZ+\sum\_{}^{}δ\_{k}CV\_{i,j,t}+v\_{i}+u\_{t}+ε\_{i,j,t}$ (4)

The regression results of model (4) are shown in column (3) of **Table 6**, where the coefficient of Pledge × Policy is significantly positive. This suggests that the role of relief policy in promoting firms' innovation is more significant in firms with a higher degree of financing constraints, and when firms receive more relief, their financing constraints are alleviated, resulting in more innovation output.

**Table 6**

Regression results of the mechanism.

|  |  |  |  |
| --- | --- | --- | --- |
|  | (1) | (2) | (3) |
|  | Risk-taking | RD Investment | Financial constraints |
| *Pledge×Policy×KZ* |  |  | 0.046\* |
|  |  | (1.67) |
| *KZ* |  |  | -0.078 |
|  |  | (-1.55) |
| *Pledge×Policy* | -0.004\*\* | 0.421\*\* | 0.161\*\*\* |
|  | (-2.07) | (2.12) | (2.81) |
| *Size* | -0.002\*\* | -0.187 | 0.473\*\*\* |
| (-2.58) | (-1.56) | (12.66) |
| *Age* | 0.001 | -0.504\*\*\* | -0.167\*\*\* |
| (1.16) | (-4.33) | (-5.05) |
| *Board* | -0.002 | 0.029 | 0.010 |
| (-0.44) | (0.04) | (0.06) |
| *LEV* | -0.020\*\*\* | -8.520\*\*\* | -0.088 |
| (-5.08) | (-12.81) | (-0.50) |
| *ROA* | 0.001\* | 0.232\*\*\* | 0.064\*\*\* |
| (1.85) | (5.94) | (5.56) |
| *Top10* | 0.012 | 4.248\* | -0.330 |
| (1.00) | (1.85) | (-0.56) |
| *INDEP* | -0.129\*\*\* | -6.664\*\*\* | 0.663\*\* |
| (-8.84) | (-5.12) | (2.18) |
| *Grant* | 0.001 | -4.481\*\*\* | -1.157\*\*\* |
| (0.32) | (-5.75) | (-5.44) |
| *RI* | 0.001 | -0.064 | 0.297\*\*\* |
| (0.60) | (-0.24) | (3.27) |
| *RF* | 0.001 | 0.519\* | 0.100 |
| (0.56) | (1.84) | (1.55) |
| Constant | 0.061\*\* | 9.183\*\* | -12.066\*\*\* |
| (2.10) | (2.21) | (-8.79) |
| Year FE | YES | YES | YES |
| Region FE | YES | YES | YES |
| N | 7,877 | 7,877 | 7,876 |
| R2 | 0.114 | 0.197 | 0.165 |

Note: Numbers in parentheses are t-statistics. \*\*\*, \*\*, or \* represent 1%, 5%, or 10% significance levels, respectively.

*Analysis of heterogeneity*

According to the theory of financing preferences established by Myers and Majluf (1984), a firm's financing constraints are positively related to the degree of information asymmetry. According to the information disclosure theory, the degree of information asymmetry of a company is largely determined by its information disclosure policy and practice, and perfect information disclosure can effectively reduce the degree of information asymmetry of a company, and then reduce the cost of external financing (Goldstein and Yang, 2017). The improvement of information disclosure level can significantly reduce the degree of information asymmetry of firms, which in turn has a beneficial effect on firms' stock liquidity, external financing costs, etc. (Wang et al., 2023), and thus affects firms' innovation. To test whether the effect of relief policy on corporate innovation is heterogeneous in terms of disclosure quality, this paper divides the sample into groups with better disclosure quality and worse disclosure quality based on the median of the KV index. The regression results after grouping are shown in **Table 7**, the coefficient of Pledge×Policy in the group of poorer disclosure quality is 0.268, while the coefficient in the group of better disclosure quality is only 0.114, and the difference of this coefficient passes Fisher's Permutation test, which indicates that the relief policy promotes corporate innovation effect is more significant for poorer disclosure quality.

**Table 7**

Heterogeneity test results.

|  |  |  |
| --- | --- | --- |
|  | Worse disclosure quality | Better disclosure quality |
|  | *Innovation* | *Innovation* |
| *Pledge×Policy* | 0.268\*\*\* | 0.114\* |
| (3.31) | (1.79) |
|  | P=0.030 |
| *Size* | 0.484\*\*\* | 0.449\*\*\* |
| (10.85) | (10.68) |
| *Age* | -0.156\*\*\* | -0.179\*\*\* |
| (-3.57) | (-4.86) |
| *Board* | 0.040 | 0.005 |
| (0.17) | (0.02) |
| *LEV* | 0.122 | -0.380\*\* |
| (0.59) | (-2.06) |
| *ROA* | 0.056\*\*\* | 0.072\*\*\* |
| (3.78) | (5.14) |
| *Top10* | 0.046 | -0.711 |
| (0.06) | (-1.15) |
| *INDEP* | 1.216\*\*\* | 0.159 |
| (2.81) | (0.47) |
| *Grant* | -1.231\*\*\* | -1.124\*\*\* |
| (-4.55) | (-4.86) |
| *RI* | 0.587\*\*\* | 0.177\* |
| (4.21) | (1.84) |
| *RF* | 0.005 | 0.201\*\* |
| (0.05) | (2.45) |
| Constant | -15.456\*\*\* | -10.422\*\*\* |
| (-7.94) | (-7.00) |
| Year FE | YES | YES |
| Region FE | YES | YES |
| N | 3,926 | 3,925 |
| R2 | 0.175 | 0.144 |

Note: Numbers in parentheses are t-statistics. \*\*\*, \*\*, or \* represent 1%, 5%, or 10% significance levels, respectively.

Innovation is the main source and core power to maintain the core competitive advantage of enterprises. To gain a competitive advantage, firms must innovate. When listed companies are located in industries with different levels of competition, they tend to face different cash flow risks (Aghion et al., 2002). The presence of cash flow risk inhibits firms from engaging in risky innovation activities (Beladi et al., 2021), and the higher the cash flow risk, the lower the willingness of firms to innovate. This paper divides the sample into firms in competitive and non-competitive industries based on the median of the sample firms' Herfindahl indexes and groups them into separate regressions, and the regression results are shown in **Table 12**. The coefficient of Pledge × Policy is significantly positive in the samples in competitive industries, and insignificant in the samples in uncompetitive industries, suggesting that the relief policy is more effective in providing relief and assistance to firms facing fierce competition, providing financial support such as cash and helping firms to innovate.

**Table 8**

Heterogeneity test results.

|  |  |  |
| --- | --- | --- |
|  | Competitive industries | Uncompetitive industries |
|  | *Innovation* | *Innovation* |
| *Pledge×Policy* | 0.074 | 0.236\*\*\* |
| (0.94) | (3.01) |
|  | P=0.040 |
| *Size* | 0.435\*\*\* | 0.570\*\*\* |
| (8.81) | (12.48) |
| *Age* | -0.166\*\*\* | -0.157\*\*\* |
| (-3.73) | (-3.79) |
| *Board* | 0.062 | -0.035 |
| (0.24) | (-0.16) |
| *LEV* | 0.053 | 0.026 |
| (0.23) | (0.13) |
| *ROA* | 0.031\* | 0.091\*\*\* |
| (1.90) | (6.37) |
| *Top10* | -0.981 | 0.005 |
| (-1.27) | (0.01) |
| *INDEP* | 0.453 | 0.492 |
| (1.03) | (1.29) |
| *Grant* | -1.183\*\*\* | -0.662\*\* |
| (-3.89) | (-2.57) |
| *RI* | 0.545\*\*\* | 0.130 |
| (3.57) | (1.28) |
| *RF* | 0.001 | 0.126 |
| (0.01) | (1.50) |
| Constant | -13.142\*\*\* | -13.073\*\*\* |
| (-6.28) | (-8.14) |
| Year FE | YES | YES |
| Region FE | YES | YES |
| N | 3,868 | 4,008 |
| R2 | 0.160 | 0.240 |

Note: Numbers in parentheses are t-statistics. \*\*\*, \*\*, or \* represent 1%, 5%, or 10% significance levels, respectively.

**Conclusions and policy implications**

Using the panel data of Chinese A-share private listed companies from 2014-2021, we construct a difference-in-difference model and have found that relief policy significantly improves corporate innovation. R&D investment and risk-taking capacity act as the mediation. The degree of financing constraints plays a positive role in the relief policy's promotion of firms' innovation. Further analysis reveals that the effect of relief policy on promoting corporate innovation is more significant for companies in competitive industries and with poorer disclosure quality. From the above conclusions, we could find that relief policy, as a short-term emergency relief policy, not only alleviates firms’ short-term equity pledge risk but also has a long-term effect of promoting corporate innovation, which enriches the research in terms of the economic consequences of relief policy. Meanwhile, when it comes to the impact of equity pledges on corporate innovation, previous studies focus on the fact that an increased equity pledge inhibits corporate innovation, but do not pay attention to whether a reduction in the equity pledge rate can promote corporate innovation. This paper’s conclusions can be used as evidence to indirectly support the question, thus bridging the research gap.

 This paper has the following two insights. In terms of policy design, local governments should introduce corresponding measures to stabilize enterprise development while balancing growth stabilization and risk prevention, helping listed companies relieve the risk of equity pledges. In terms of policy implementation, this paper helps local governments identify the focus point for implementing governmental relief policy and continuously refine the direction of guidance. Local governments can strengthen the supervision of the action of relief and consider improving the policy of adding a deduction for R&D expenses to alleviate the pressure on corporate innovation of listed companies. Listed companies should actively respond to national policies, grasp policy support, adopt optimal investment decisions, and increase R&D investment to improve innovation performance.

This study has some limitations. First, we focus only on private listed companies and other companies are not included in the current study. Second, after 2021, some provinces that did not conduct relief policies in 2018 started to do so, this study does not consider and measure the effects of the relief policies carried out in these provinces. These limitations signal the scope for future

research.

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