



Political turnover and firm innovation in China: The moderating role of innovation and entrepreneurship environment

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ABSTRACT

The empirical work in this paper is based on an analysis of the data of China's listed companies, the innovation and entrepreneurship index, and local official turnover data at the city level. It shows that policy uncertainty caused by local political turnover in local governments significantly reduces firm innovation. However, improvement in local innovation and entrepreneurship environment can lessen this negative impact. This moderating effect is especially relevant among non-high-tech or financially constrained firms. The robustness of these findings is checked through a series of alternative analyses such as dealing with endogeneity, optional measures of the dependent variable and subsamples.

1. Introduction

Firm innovation plays a vital role in China's transition to an innovative country (Cheng & Lei, 2015; Fagerberg, 2018). It is characterized by massive investment, high risk, uncertainty and irreversibility (Bhattacharya et al., 2017; Cheng et al., 2019). These features make firm innovation vulnerable to both internal factors and the external environment (Li, 2009; Shi & Wu, 2017). Government policy certainty is an essential external factor affecting firm innovation (Bhattacharya et al., 2017). Under China's current administrative system, there are periodic or abrupt changes of officials in local governments (Deng et al., 2019). Statistics show that local officials are generally transferred before their term ends (Feng & Johansson, 2017; Bu et al., 2020). When local officials are replaced, if newly appointed ones simply follow the blueprint laid down by their predecessors, any credit of success may go to the former officials (Zhong et al., 2019). Therefore, newly appointed officials are likely to adopt new policies for their own interests (Cumming et al., 2016). The associated policy uncertainty would affect firms' of in innovation investment decisions (Feng & Johansson, 2017; Luo & Zhang, 2022).

In addition, it is argued that a good institutional environment could reduce uncertainty and ease coordination between economic agents and hence greatly promotes firm innovation (Alonso & Garcimartín, 2013; Wang et al., 2019; Donbesuur et al., 2020). In contrast, a poor institutional environment could undermine the functioning of factor markets, increase transaction costs and magnify information asymmetry (Meyer et al., 2009). Recently, China's central government emphasised the importance of sound innovation and entrepreneurship environment in promoting innovation. Has this campaign contributed to a boost in firm innovation? Can good innovation and entrepreneurship environment help alleviate the negative impact of policy uncertainty? Understanding these questions has implications for innovation-driven development in China as well as other emerging economies.

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The objective of this study is to investigate the impact of political turnover on firm innovation, and particularly whether a sound innovation and entrepreneurship environment could alleviate the negative impact of policy uncertainty. The findings show that policy uncertainty has a significant and negative impact on firm innovation and a sound innovation and entrepreneurship environment could lessen this negative impact. However, the moderating role of innovation and entrepreneurship environment is present mainly in firms which are non-high-tech or financially constrained.

This paper makes several contributions to the literature. First, this study clarifies the relationship between political turnover and firm innovation in an emerging economy, namely China, where promotion competition or tournament widely exists and the economy is undergoing through transformation to an innovation-driven one. Previous studies generally focused on the impacts of political turnover or policy uncertainty on firms' investment (An et al., 2016; Gulen & Ion, 2016; Drobetz et al., 2018; Chen et al., 2019; Kong et al., 2022) or R&D investment (Cumming et al., 2016; Luo & Zhang, 2022; Cui et al., 2021), without considering the innovation performance and distinguishing the difference between quantity and quality of innovation. In addition, most of these studies are related to developed countries or cross-country studies rather than emerging countries (Pertuze et al., 2019; Xu, 2020; William & Fengrong, 2022). Chen (2021) and Zhang et al. (2022) are exceptions. These authors studied the relationship between political turnover and firm innovation in China but obtained conflicting results. The present study investigates the relationship between political turnover and innovation in China by considering both the quantity and quality of innovation and clarifying the relationship between political turnover and firm innovation in China in more depth, and hence fills the gap in the literature.

Second, this study may be the first to explore how the innovation and entrepreneurship environment affects the relationship between political turnover and firm innovation. The extant literature generally focused on the institutional environment (Huang et al., 2015; Julio & Yook, 2016; Wu et al., 2019; Urbano et al., 2020) or the business environment (Contractor et al., 2020; Gogokhia & Berulava, 2021; Wang et al., 2023). However, the innovation and entrepreneurship environment is closely related to innovation (Dubina et al., 2017) and hence deserves special attention. This study integrates political turnover, innovation and entrepreneurship environment, and firm innovation into a single framework. The moderating role of innovation and entrepreneurship environment is discussed in depth, which has not yet been explored. In the context of China's current emphasis on fostering a better innovation and entrepreneurship environment to support an innovation-driven strategy, our findings provide new insight understanding the development of China's innovation and entrepreneurship environment and offer further suggestions for coping with the shock of political turnover or policy uncertainty. The Chinese experience also has important implications for other developing countries.

The rest of the paper begins with a literature review and hypothesis development in Section 2. This is followed by the discussion of data, modelling issues and choice of variables in Section 3. The baseline modelling results are presented in Section 4. The robustness of the findings is checked in Section 5. Finally, Section 6 concludes the paper.

2. Literature review and research hypotheses

2.1. Policy uncertainty and firm innovation

Since a large part of R&D spending is the salary of researchers, firm innovation investment is irreversible (Gulen & Ion, 2016; Pertuze et al., 2019). Once firm managers think that external uncertainty affects firm earnings, they may postpone investment until the uncertainty disappears. Local officials in China have the power of resource allocation. Different officials have various incentives and preferences (Cao et al., 2016). Therefore, local political turnover inevitably will change the external policy environment of firms. Although firm managers could adapt to these changes, they cannot foresee the new policy environment. This uncertainty will increase the value of waiting options (Bernanke, 1983) and hence inhibits firms' investment in innovation (Luo & Zhang, 2022). Relevant studies demonstrated that policy uncertainty had adverse effects on firm investment (An et al., 2016; Gulen & Ion, 2016), particularly investment in innovation (Feng & Johansson, 2017; Cong & Howell, 2021). Thus, the following hypothesis is proposed:

H1. : Policy uncertainty is detrimental to firm innovation, *ceteris paribus*.

2.2. The moderating role of innovation and entrepreneurship environment

The importance of institutional environment in supporting firms innovation has been widely confirmed. Good institutional environment not only provides an institutional guarantee but also reduces external uncertainty (Minniti, 2008). Julio and Yook (2016) used the timing of national elections to measure political uncertainty. They found that policy uncertainty negatively affects foreign investment, while countries with better institutional quality experience significantly less variation in foreign investment around election cycles. The present study focuses on innovation and entrepreneurship environment which plays an essential supporting role in the regional innovation system and is the key to improve innovation efficiency and capability (Furman et al., 2002; Li, 2009; Chen & Guan, 2011).

Specifically, innovation environment is an essential determinant of innovation efficiency and capability (Li, 2009). The innovation process and innovation environment are intrinsically linked and intertwined (Dubina et al., 2017). In regions with poor innovation environment, it is difficult for firms to obtain the resources needed for innovation from the market (Wang et al., 2019). Therefore, good innovation environment can promote firm innovation (Fernández Fernández et al., 2015) and reduce various uncertainties (Maillat, 1995). Meanwhile, good innovation and entrepreneurship environment generally implies that the market plays a more dominant role. This market-oriented environment will reduce government intervention distortion and alleviate the negative impact caused by political turnover. Thus, the following hypothesis is proposed:

H2. : Improvement in innovation and entrepreneurship environment lessens the negative impact of policy uncertainty on firm innovation, *ceteris paribus*.

2.3. . Heterogeneous effects

Financial constraint is a severe challenge to technological innovation due to the high risk and uncertain nature of innovation activities (Cheng et al., 2019). Policy uncertainty would increase the cost of external financing (Xu, 2020) and aggravate the financial constraints of firms (Pástor & Veronesi, 2013; Brogaard & Detzel, 2015; Phan et al., 2019). Cumming et al. (2016) found that access to loans would positively affect the possibility of firm investment in innovation, which was significantly weakened by political instability. When policy uncertainty increases, obtaining financing will be more challenging, and the value of waiting options will increase substantially for financially constrained firms (Cui et al., 2023). Therefore, financially constrained firms are more vulnerable to political turnover (Guariglia & Liu, 2014; Xu, 2020).

A significant component of the innovation system is the financial system which is responsible for financing innovation (Li et al., 2009; Wang et al., 2016). Firms in regions with developed financial systems face lower barriers to financing resources (Demircug-Kunt et al., 2006). Therefore, the innovation and entrepreneurship environment improves as the financial system develops. Firms, especially financially constrained firms, may have easier access to innovation resources, including finance, thus reducing the negative impact of policy uncertainty. Therefore, the following hypothesis is proposed:

H3a. The moderating role of innovation and entrepreneurship environment is mainly manifested in financially constrained firms, *ceteris paribus*.

High-tech firms play a crucial role in technological progress through R&D and innovation (Hirschey et al., 2012). Therefore, China has actively promoted the innovation activities of high-tech firms (Su et al., 2019). If firms are recognized as high-tech, they enjoy various tax preferences and reductions (Dang et al., 2019). In addition, high-tech firms have easier access to private financing resources due to their potential to create valuable innovations (Su et al., 2019). Compared to high-tech firms, non-high-tech firms can obtain financial support from the government only by building political relationships (Su et al., 2019). In addition, when economic policy uncertainty increases, local governments tend to enhance taxation for non-high-tech firms (Dang et al., 2019), which leads non-high-tech firms are more inclined to squeeze out innovation investment to alleviate financing constraints and reduce risks (Ya et al., 2018). Therefore, non-high-tech firms are more sensitive to policy uncertainty (Dang et al., 2019). Based on this, non-high-tech firms are more sensitive to optimizing the innovation and entrepreneurship environment. Thus, the following hypothesis is proposed:

H3b. The moderating role of innovation and entrepreneurship environment is mainly manifested in non-high-tech firms, *ceteris paribus*.

3. . Research design

3.1. . Data issues

This study is based on listed companies in Shanghai and Shenzhen A-share Markets from 2008 to 2018. The dataset is trimmed by excluding financial companies, ST, *ST, suspended, terminated, and delisted companies during the sample period, and companies with missing data. The final sample consists of 4360 company-year observations. Appendix A1 shows the sample distribution by year. To avoid the influence of outliers on the regression results, the final sample is shrunk at the 1 % percentile tail of all continuous variables.

Personal information of the mayors and party secretaries of each city is manually collected from the "Chronicles of Local Party and Government Leaders" compiled by China Economic Net and "Database of Party and Government Leaders of China" published by the Communist Party of China News website. The accuracy of the data is further verified by using information from relevant Baidu and Google websites. Firm patent and financial data are drawn from the CNRDS and CSMAR database. The innovation and entrepreneurship environment index at the city-level is sourced from Center for Enterprise Research of Peking University.

3.2. . Empirical specifications

The following models are adopted to verify the proposed hypotheses:

$$Innovation_{i,j,m,t} = \beta_0 + \beta_1 gt_{m,t} + \beta_2 \mathbf{X}_{i,t} + \delta_i + \theta_{t,j} + \varepsilon_{i,t} \quad (1)$$

$$Innovation_{i,j,m,t} = \beta_0 + \beta_1 gt_{m,t} + \beta_2 index_{m,t} + \beta_3 gt_{m,t} \times index_{m,t} + \beta_4 \mathbf{X}_{i,t} + \delta_i + \theta_{t,j} + \varepsilon_{i,t} \quad (2)$$

^② ST and *ST companies refer to firms that suffer from continuous losses and are under special treatment. The original data consists of 28,479 company-year observations. After excluding the financial companies, 27,892 company-year observations are left. After excluding ST, *ST, suspended, terminated, and delisted firms during the sample period, 21,573 company-year observations remain. After excluding observations with missing moderating variables, 17,302 company-year observations are left. After excluding observations with missing values of relevant control variables, 16,265 company-year observations remain. Finally, after excluding observations with missing patent citation data, only 4360 company-year observations remain in the sample.

where the dependent variable $Innovation_{i,j,m,t}$ is the innovation output of firm i in year t (in industry j and city m). The independent variable $gt_{m,t}$ represents the policy uncertainty index of city m in year t . The moderating variable $index_{m,t}$ is the index of innovation and entrepreneurship environment in city m and year t . X is a vector of control variables including firm size ($size$), the proportion of fixed assets ($tangility$), asset-liability ratio ($leverage$), return on assets (roa), the shareholding ratio of the largest shareholder ($lrghldr$), the proportion of independent directors ($indrcreat$) and growth opportunities ($tobinq$). δ_i represent the fixed effects, $\theta_{i,j}$ represents the cross-product term of year and industry level fixed effects to control the unobserved factors at the industry level over time, $\varepsilon_{i,t}$ represents the random error term. Table 1 shows the definitions of main variables.

3.3. Key variables

Firm innovation (Innovation): We consider firm innovation from two perspectives, namely innovation quantity ($innovnum$) and innovation quality ($innovqua$). The total number of patent applications represents the quantity of firm innovation. We chose the number of patent applications rather than patent grants to measure the quantity of firm innovation because the approval of patents takes 1–4 years while the year of patent applications is more consistent with the time when the firm makes the decision (Bhattacharya et al., 2017; Pertuze et al., 2019). Furthermore, the citation of patents is employed to measure the quality of firm innovation as used by other scholars (Bhattacharya et al., 2017; Cong & Howell, 2021). To deal with zero number of patent applications and patent citations for some firms in some years, the natural logarithm of the number of patent applications and patent citations plus 1 is used in empirical analysis.

Policy uncertainty (gt): This study adopts the party secretary turnover of cities to reflect policy uncertainty. The variable gt takes value 1 if the city's party secretary is replaced in that year and zero otherwise (Feng & Johansson, 2017; Zhong et al., 2019). There are two main reasons for considering party secretary turnover. First, China's central government has delegated financial and administrative powers to local governments which have the decision-making power in their regions (Luo & Zhang, 2022). Second, under the current administrative system in China, the local party secretaries are effectively in charge and can hence directly determine the allocation of resources.

Innovation and entrepreneurship environment ($index$): The innovation and entrepreneurship index compiled by Center for Enterprise Research of Peking University is adopted to measure local innovation and entrepreneurship environment. The higher the index score is, the better the regional innovation and entrepreneurship environment is. This index has two characteristics. First, it emphasises the market identification mechanism of innovation and entrepreneurship. That is, it examines the actual output rather than the input of firm innovation and entrepreneurship in a region and thus provides a more objective and accurate evaluation of innovation and entrepreneurship. Second, the database is more comprehensive as it includes all industries and firms of all sizes in China, especially the small and medium firms (SMEs) being actively engaged in innovation and start-up firms. Table 2 shows the composition of innovation and entrepreneurship index. First, all the fundamental indicators were logarithmic and then standardized based on the z-score method. Second, the standard values of the index were based on the weights. Finally, the standard values of the index were transformed into quartiles that obey the standard normal distribution.

3.4. Descriptive statistics

Table 3 shows the descriptive statistics of the variables. For $innovnum$ and $innovqua$, the mean values are much higher than the median, indicating that the numbers of patent applications and patent citations are right-skewed. The mean value of policy uncertainty (gt) indicates that about 29 per cent of cities have changed their party secretaries during the sample period. The maximum and minimum values of the moderating variable innovation and entrepreneurship environment ($index$) are 100 and 19.11, with a standard deviation of 19.15. Thus, there are noticeable differences in innovation and entrepreneurship environment across the cities.

4. Empirical results

4.1. Testing hypotheses H1 and H2

Table 4 reports the baseline regression results. Each regression controls firms' characteristics and individual and year-industry fixed effects. Since the key explanatory variables, gt and $index$, are measured at the prefecture-level, the standard errors are clustered at the prefecture-level.

First, columns (1) and (4) in Table 4 show that the coefficient of gt is significantly negative at 1% and 5%, respectively.¹ This result indicates that policy uncertainty has a significant negative impact on both the quantity and quality of firm innovation outcome. Therefore, hypothesis H1 is confirmed. Second, columns (2) and (5) illustrate that the coefficient of gt is still significantly negative. The

¹ An anonymous referee pointed out that there may be time lags in firms' response to political turnover. We thus tried to use lagged innovation variables (both 1 and 2 lags) in Eqs. (1) and (2). The estimated coefficient of gt (political uncertainty index) is either insignificant (for 1 lag) or significant at 5% for the number of patent applications only. Fang et al. (2023) argued that some firms such as politically connected or state-owned firms may learn of scheduled official turnover in advance and hence reduce their R&D investment, affecting patent applications. Thus, officials' turnover may only affect firms' patent applications in the current year.

Table 1
Variable definitions.

Variable	Definition
<i>innovnum</i>	The number of patent applications.
<i>innovqua</i>	The number of patent citations.
<i>gt</i>	A dummy variable taking a value of one if a city experiences a party secretary turnover in a year, and zero otherwise.
<i>index</i>	The index of innovation and entrepreneurship environment of a city in a given year.
<i>size</i>	The natural logarithm of total firm assets at the end of a year.
<i>tangility</i>	The ratio of fixed assets to total assets.
<i>leverage</i>	The ratio of total liabilities to total assets.
<i>roa</i>	The ratio of net profit to total assets.
<i>lrghldrt</i>	The shareholding percentage of the largest shareholder.
<i>indrcrat</i>	The percentage of independent directors.
<i>tobinq</i>	The ratio of market value to total assets.

Source: Authors' own work.

Table 2
The composition of innovation and entrepreneurship index.

Dimensions	Fundamental indicators	Weights
New-established enterprises	Number of new enterprise registrations.	20%
Attracting foreign investments	Number of new investments by foreign legal persons.	15%
Attracting venture capitals	Number of new companies with venture capitals.	25%
Number of patent authorizations	Number of new invention patent authorizations.	12.5%
	Number of new utility model patent disclosures.	7.5%
Number of trademark registrations	Number of new design patent disclosures.	5%
	Number of new trademark registrations.	15%

Source: Index of Regional Innovation and Entrepreneurship in China, Center for Enterprise Research, Peking University.

Table 3
Descriptive statistics of variables.

Variable	N	Mean	SD	Min	Median	Max
<i>innovnum</i>	4360	34.9576	131.8120	0.0000	9.0000	5820.0000
<i>innovqua</i>	4360	21.6539	89.1848	0.0000	1.0000	2186.0000
<i>gt</i>	4360	0.2924	0.4549	0.0000	0.0000	1.0000
<i>index</i>	4360	84.0585	19.1470	19.1126	91.4676	100.0000
<i>size</i>	4360	22.1902	1.1164	20.1517	22.0807	25.0340
<i>tangility</i>	4360	0.2375	0.1554	0.0045	0.2184	0.6374
<i>leverage</i>	4360	0.4868	0.1780	0.1115	0.4912	0.8343
<i>roa</i>	4360	0.0396	0.0407	-0.0715	0.0328	0.1601
<i>lrghldrt</i>	4360	0.3456	0.1408	0.1072	0.3232	0.7237
<i>indrcrat</i>	4360	0.3962	0.0760	0.2143	0.3750	0.6000
<i>tobinq</i>	4360	1.8435	0.9142	0.9122	1.5502	5.5104

Source: Authors' own work.

coefficient of *index* is significantly positive in column (2) but insignificant in column (5). In general, better innovation and entrepreneurship environment would boost firm innovation. Finally, the coefficient of *gt_index* is significantly positive in column (3) but insignificant in column (6). This finding indicates that an improvement in innovation and entrepreneurship environment can promote firm innovation and reduce the negative impact of policy uncertainty on firm innovation. However, this moderating effect is only reflected in the quantity of firm innovation outcome. Hypothesis H2 is hence partially supported. One possible explanation of this partial support is the fact that high quality innovation requires long-term investment. Given the current institutional background, Chinese local leaders often favor innovation projects that can be commercialised in the short-term and used to support their promotion. Subsequently, the distribution of regional innovation resources may be inclined to promote the quantity of firm innovation outcome.

4.2. . Testing hypotheses H3a and H3b

Policy uncertainty increases the risk of the financial market (Pástor & Veronesi, 2012; Huang et al., 2015). Belke et al. (2018) examined the data of 19 major European countries and found that policy uncertainty due to Brexit leads to the instability of the financial market. Furthermore, with the increase of uncertainty, companies are less likely to obtain loans from banks (Ren et al., 2020). Subsequently, financial constraints would restrict the growth of firms and may further inhibit the firms' innovation activities (Ayyagari et al., 2008; Guariglia & Liu, 2014). Therefore, for firms with greater financial constraints, the negative impact of policy uncertainty is

Table 4
Results of testing H1 and H2.

	innovnum			innovqua		
	(1)	(2)	(3)	(4)	(5)	(6)
gt	-0.0693*** (-2.6182)	-0.0684** (-2.6004)	-0.0686*** (-2.7536)	-0.0779** (-2.1333)	-0.0770** (-2.1145)	-0.0771** (-2.1663)
index		0.1469** (2.2236)	0.1203* (1.8059)		0.1369 (1.6331)	0.1262 (1.4719)
gt_index			0.0678*** (2.7199)			0.0273 (0.6727)
size	0.5365*** (8.0499)	0.5338*** (8.0129)	0.5322*** (7.9929)	0.2384*** (2.8478)	0.2359*** (2.8166)	0.2353*** (2.8078)
tangility	0.0220 (0.0798)	0.0213 (0.0771)	0.0225 (0.0816)	-0.8686*** (-3.0404)	-0.8693*** (-3.0325)	-0.8688*** (-3.0286)
leverage	-0.4498** (-2.2005)	-0.4531** (-2.2189)	-0.4440** (-2.1763)	-0.3419 (-1.2894)	-0.3450 (-1.3013)	-0.3414 (-1.2865)
roa	0.3416 (0.6743)	0.2869 (0.5685)	0.3121 (0.6159)	1.3931** (2.0316)	1.3421* (1.9320)	1.3522* (1.9428)
lrghldrt	-0.4488 (-1.0430)	-0.4324 (-1.0015)	-0.4276 (-0.9952)	0.2363 (0.5642)	0.2517 (0.5981)	0.2536 (0.6038)
indrctat	-0.2591 (-1.3158)	-0.2751 (-1.4046)	-0.2740 (-1.4094)	-0.2453 (-1.0323)	-0.2603 (-1.0924)	-0.2598 (-1.0894)
tobinq	-0.0172 (-0.6776)	-0.0172 (-0.6891)	-0.0183 (-0.7307)	0.0109 (0.2963)	0.0109 (0.3004)	0.0105 (0.2859)
Constant	-10.1611*** (-7.3193)	-10.0931*** (-7.2848)	-10.0427*** (-7.2692)	-3.7439** (-2.0583)	-3.6833** (-2.0290)	-3.6630** (-2.0170)
R ²	0.3037	0.3052	0.3063	0.3943	0.3950	0.3952

Note: *, **, and *** represent the significance level of 10 %, 5 %, and 1 %, respectively. Standard errors are clustered at the prefecture-level, with value in parentheses. All regressions include firm fixed effects and industry-year pair fixed effects. The sample size is 4360.

more significant.

In this section, we investigate differences in the moderating role of innovation and entrepreneurship environment for firms under financial constraints. An index defined by [Hadlock and Pierce \(2010\)](#) is used to measure financial constraints of firms. This index is based on firm size and age (and hence called the SA index). Its calculation is based on this formula: $SA = -0.737 \times SIZE + 0.043 \times SIZE \times SIZE - 0.04 \times AGE$ ($SIZE = \ln(\text{total assets}/1000000)$ and AGE is the years of the firm being listed). The SA index is negative, and the larger its absolute value is, the more serious the financial constraint is. After taking the absolute value of the SA index, we divide the sample into financially constrained firms and others according to the median value of the annual-industry SA index.²

[Table 5](#) shows that only the coefficient of *gt* for firms with high financial constraints is negative and significant, indicating that the detrimental effect of policy uncertainty is more evident among financially constrained firms. Columns (3) and (4) of [Table 5](#) demonstrate that the improvement in the innovation and entrepreneurship environment can alleviate the negative impact of policy uncertainty on innovation of firms under financial constraints. Thus, hypothesis H3a is confirmed. In addition, this moderating effect is mainly reflected in the quantity of firm innovation.

Finally, the effect of policy uncertainty on firm innovation may also be affected by firm qualification. China's government has been actively promoting the development of high-tech industry ([Liu & Buck, 2007](#)). For example, high-tech firms can obtain a preferential income tax rate of 15 %. Therefore, as the key object of national support, high-tech firms are less affected by policy uncertainty. According to the *Administrative Measures for the Determination of High and New Technology Enterprises* issued in 2016, we divide the sample into high-tech and non-high-tech firms according to whether a firm belongs to the *High-Tech Fields Supported by the State*. [Table 6](#) shows that only the coefficient of *gt* for non-high-tech firms is negative and significant, indicating that the detrimental effect of policy uncertainty is more evident in non-high-tech firms. Further analysis in [Table 6](#) shows that only the coefficient of the *gt_index* in column (7) is positive and significant. These results demonstrate that the moderating role of innovation and entrepreneurship environment mainly exists in non-high-tech firms. Therefore, hypothesis H3b is confirmed. Once again, this moderating effect is mainly reflected in the quantity of firm innovation outcome.

4.3. Endogeneity issues

The analysis in may suffer from endogeneity due to potential selection bias and reversal causality. To solve the endogeneity issues, we combine the Heckman two-stage estimation method and 2SLS.

First, local party secretaries generally retire at 60 and have average tenure of five years. Thus, local political turnover may be

² Thanks to an anonymous referee's suggestion, we considered using SA index as a continuous variable and constructed the interaction term *gt_sa* between the variable *gt* and SA for further analysis. This however becomes problematic as the correlation coefficient between variable *gt* and *gt_sa* is high (about 0.997*** while that between *gt* and *gt_index* is very low, 0.012).

Table 5
Regression results of testing hypothesis H3a.

	Financially constrained firms				Other firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>
<i>gt</i>	-0.0998*** (-2.8060)	-0.1258*** (-2.7547)	-0.0946*** (-2.7648)	-0.1230*** (-2.8083)	-0.0561 (-1.3862)	-0.0595 (-1.1733)	-0.0591 (-1.4809)	-0.0583 (-1.1079)
<i>index</i>	0.2762*** (2.8046)	0.1601 (1.5084)	0.2377** (2.3686)	0.1390 (1.3498)	0.0470 (0.4863)	0.0906 (0.6371)	0.0304 (0.3063)	0.0976 (0.6424)
<i>gt_index</i>			0.0890** (2.4673)	0.0488 (0.8986)			0.0455 (1.3566)	-0.0192 (-0.3150)
<i>Constant</i>	-8.0179*** (-3.6870)	-2.9622 (-1.2806)	-7.9794*** (-3.6739)	-2.9411 (-1.2723)	-12.0223*** (-5.5984)	-2.9578 (-1.1695)	-12.0029*** (-5.5936)	-2.9651 (-1.1715)
N	2137	2137	2137	2137	2223	2223	2223	2223
R ²	0.3347	0.4260	0.3369	0.4264	0.3449	0.4258	0.3454	0.4258

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

Table 6
Regression results of testing hypothesis H3b.

	High-tech firms				Non-high-tech firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>
<i>gt</i>	-0.0545 (-1.4334)	-0.0774 (-1.3307)	-0.0518 (-1.3747)	-0.0790 (-1.3595)	-0.0785** (-2.2127)	-0.0826** (-2.0045)	-0.0832** (-2.4322)	-0.0861** (-2.1399)
<i>index</i>	0.1417 (1.4211)	0.1369 (1.0907)	0.1228 (1.1979)	0.1484 (1.1887)	0.1837** (2.1573)	0.1584 (1.5857)	0.1450* (1.7029)	0.1295 (1.2348)
<i>gt_index</i>			0.0480 (1.5854)	-0.0291 (-0.4358)			0.0948** (2.3011)	0.0709 (1.5443)
<i>Constant</i>	-11.9223*** (-4.9267)	-4.7745 (-1.2988)	-11.9068*** (-4.9239)	-4.7839 (-1.3014)	-11.9279*** (-7.0077)	-1.9457 (-1.1086)	-11.8933*** (-6.9961)	-1.9170 (-1.0922)
N	1803	1803	1803	1803	2557	2557	2557	2557
R ²	0.3286	0.4669	0.3292	0.4670	0.3036	0.3482	0.3057	0.3491

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

$$probit(gt_{m,t}) = a_0 + a_1Tenure_{m,t} + a_2Age_{m,t} + \eta_t + \mu_m + \varepsilon_{m,t} \tag{3}$$

expected in some circumstances and company managers can adjust their decisions in innovation investment before the local official replacement (Feng & Johansson, 2017). For this reason, Heckman two-stage estimation method is employed to address the issue of selection bias. A Probit model is considered with policy uncertainty (gtm, t) as the dependent variables, and the tenure (Tenure,m,t) and

Table 7
Regression results of Heckman two-stage.

	Heckman two-stage		
	First-stage	Second-stage	
	(1)	(2)	(3)
<i>gt</i>	<i>gt</i>	<i>innovnum</i>	<i>innovqua</i>
		-0.0635** (-2.4294)	-0.0725** (-2.0615)
<i>imr</i>		0.0508 (0.9998)	0.0387 (0.5615)
<i>Tenure</i>	-0.2103*** (-14.2243)		
<i>Age</i>	0.0147* (1.7835)		
<i>Constant</i>	-0.8166 (-1.2955)	-10.2980*** (-7.2921)	-3.8708** (-2.1040)
N	4288	4288	4288
R ²		0.3074	0.3979
Pseudo-R ²	0.1215		

Note: Column (1) includes year fixed effects and city fixed effects. Columns (2) and (3) include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

age ($Agem_{it}$) of officials as independent variables. The inverse mills ratio (imr) was calculated by using this following model. where $Tenure_{mt}$ and $Agem_{mt}$ are the tenure and age of the party secretary in city m in year t . η_t and μ_m represent the year and city fixed effects, respectively. The results in column (1) of Table 7 show that the tenure and age of the party secretary are significantly related to the variable gt . Thus, these two variables affect political turnover. The results in columns (2) and (3) of Table 7 show that the inverse mills ratio (imr) is insignificant, indicating that the self-selection problem is not serious. More importantly, the variable gt remains significantly negative.

In addition, we further verify whether the tenure and age of the party secretary affects firm innovation. The regression results in Table A2 of the appendix indicate that the tenure and age of the party secretary do not affect firm innovation. Therefore, the exclusion restriction variables affect political turnover but not firm innovation. Thus, the tenure and age of the party secretary are valid exclusion restriction variables.

Second, enterprise innovation may also affect the innovation and entrepreneurship environment. To deal with reversal causality, following the literature, the average score of the innovation and entrepreneurship environment indexes of the three cities closest to the GDP in the province is used as the instrumental variable (Chong et al., 2013). It is argued that governments of cities with similar GDP within the province have certain similarities in their behaviour (Chong et al., 2013), and they observe, imitate, and compete with each other, forming a "homogeneous group effect" in decision-making. Therefore, the innovation and entrepreneurship environment in cities with similar GDP in the province is highly correlated. Furthermore, "geographical segmentation" makes it difficult for the innovation of enterprises within the target city to directly influence the innovation and entrepreneurship environment of prefecture-level cities with similar GDP within the province. Therefore, the instrumental variable meets the two requirements of IV, namely: correlation and exogeneity.

Table 8 reports the 2SLS regression results. The first stage regression results shows that the instrumental variable $index_iv$ in columns (1) and (4) of Table 8 is positive and statistically significant. We use the cross product of gt and $index_iv$ as the instrumental variable of gt_index , the instrumental variable gt_index_iv in column (5) of Table 8 is positive and significant, indicating that the instrumental variables $index_iv$ and gt_index_iv are validly. The second stage results in columns (2) and (3) of Table 8 show that the coefficient of gt is significant and negative and only the coefficient of $index$ in column (2) is significant and positive. Columns (6) and (7) in Table 8 show that the coefficient of gt is significant and negative and only the coefficient of gt_index in column (6) is significant and positive, which are consistent with those in Table 4. Furthermore, the results of Kleibergen-Paap rk LM statistic reject the hypothesis that instrumental variables were insufficient identification at the 1% significance level. In addition the Cragg-Donald F statistic was much larger than the threshold of the Stock-Yogo weak instrumental variable, indicating no weak instrumental variable problem. Therefore, Hypotheses H1 and H2 are still confirmed.

We also carry out a preliminary test of the exogeneity of the instrumental variable. Following Conley et al. (2012), we first directly examine the influence of variable $index_iv$ on the quantity and quality of firm innovation outcome. Columns (1) and (2) in appendix Table A3 show that the coefficient of instrumental variable $index_iv$ is only significantly positive in column (1). Next, the results of columns (3) in appendix Table A3 show that the coefficient of instrumental variable $index_iv$ is positive but insignificant, while the coefficient of variable $index$ is significantly positive. This result indicates that the explanatory power of instrumental variable $index_iv$ to the model is absorbed by variable $index$. The results of columns (4) in appendix Table A3 show that neither the instrumental variable $index_iv$ nor the variable $index$ is significant. The results in columns (5) to (8) of appendix Table A3 are similar to columns (1) to (4) of appendix Table A3. Therefore, the instrumental variables meet the requirements of exogeneity.

Furthermore, referring to Berkowitz et al. (2012), we performed exclusion restriction tests on the instrumental variables, and the p-values of the Anderson-Rubin test $FAR(P)$ statistic in Table 8 are all greater than 0.1, implying that the null hypothesis cannot be rejected, indicating that the instrumental variables satisfy the exclusion restriction condition. ^③ Therefore, the instrumental variables are exogenous.

Similarly, the IV method is employed to repeat the exercises of testing hypotheses H3a and H3b. The results are reported in the appendix (Tables A4 and A5). In general, there is some evidence that the results of testing hypothesis 3a are affected by endogeneity (Table A4 vs Table 5). However, hypothesis 3b is still supported (Table A5 vs Table 6).

5. . Robustness checks

In this section, the robustness of the findings in Section 4 is checked in several ways. These include alternative measures of the dependent variable and key independent variables, the use of different estimation models, as well as the removal of 2012 observations. The latter is due to the fact that the year 2012 coincided with the change of leaders in China which may have a national level shock effect.

First, patents include invention patents, utility model patents and design patents. As an alternative measure of the dependent variable, we adopt the number of invention patent applications to measure the quantity of firm innovation. We also use the number of patent citations excluding self-citations to measure the quality of firm innovation. Columns (1) and (2) of Table 9 show that the results are generally consistent with those of the baseline models and hence support hypotheses H1 and H2.

Second, the turnover of both party secretary and mayor of a city could affect firm behavior. As an alternative measure of policy uncertainty, the turnover of either secretary or mayor of a city is considered. Results of the repeated exercise are reported in columns

^③ Note: The FAR statistic reports the P-value of the probability of the Fractionally Resampled Anderson-Rubin test after 10000 replicate samples.

Table 8
Results of IV estimation.

	First-stage			Second-stage			
	(1) index	(2) innovnum	(3) innovqua	(4) index	(5) gt_index	(6) innovnum	(7) innovqua
<i>gt</i>	-0.0021 (-0.1959)	-0.0644** (-2.5096)	-0.0745** (-2.1804)	-0.0025 (-0.2297)	-0.0308 (-0.4075)	-0.0638*** (-2.7078)	-0.0742** (-2.2813)
<i>index</i>		0.5631* (1.7364)	0.1980 (0.3957)			0.5200 (1.5776)	0.1739 (0.3467)
<i>gt_index</i>						0.0837** (2.0598)	0.0469 (0.8784)
<i>index_iv</i>	0.2025*** (3.4873)			0.1983*** (3.4603)	-0.1135* (-1.9472)		
<i>gt_index_iv</i>				0.0131 (0.8926)	0.6812*** (7.7435)		
<i>imr</i>	0.0035 (0.2062)	0.0517 (1.0372)	0.0556 (0.8686)	0.0052 (0.2975)	0.0481 (1.1613)	0.0552 (1.1026)	0.0576 (0.9001)
<i>Constant</i>	0.8107* (1.9198)	-9.7071*** (-6.1697)	-2.7645 (-1.4963)	0.8157* (1.9321)	-0.1053 (-0.2235)	-9.6415*** (-6.1382)	-2.7278 (-1.4771)
N	4288	4288	4288	4288	4288	4288	4288
R ²		0.8173	0.7323			0.8178	0.7324
Kleibergen-Paap rk LM statistic	13.44***	13.44***	13.44***	13.41***	13.41***	13.41***	13.41***
Cragg-Donald Wald F statistic	122.22	122.22	122.22	60.65	60.65	60.65	60.65
FAR statistic-P value		0.3217	0.3192			0.3412	0.3551

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

(3) and (4) of Table 9. These are generally consistent with those of the baseline model. Once again hypotheses H1 and H2 are confirmed.

Third, we use the "unit area score" of the index to measure the innovation and entrepreneurship environment.^④ The estimation results are listed in columns (5) and (6) of Table 9 and still support hypotheses H1 and H2. We also use the Marketization Index of Chinese provinces measured by Wang et al. (2021) and the China Urban Innovation Index published by Kou and Liu (2017) as moderating variables for robustness checks. The estimation results in appendix Table A6 still support hypotheses H1 and H2.

Fourth, following Correia et al. (2020), we use the ppmlhdfc model. The estimation results are listed in columns (7) and (8) of Table 9 are generally consistent with the baseline results. Hypotheses H1 and H2 are still confirmed.^⑤

Finally, the year 2012 coincided with the change of central government in China (Bu et al., 2020). To avoid the national level shock, we further exclude the sample of 2012 as other scholars did (An et al., 2016). The main results are reported in columns (9) and (10) of Table 9 and are generally consistent with the findings of the baseline exercise. Therefore, hypotheses H1 and H2 still hold.

6. . Conclusions

This study empirically analyses the impact of policy uncertainty on firm innovation and the moderating role of innovation and entrepreneurship environment. It is shown that policy uncertainty has a significantly negative impact on firm innovation and good innovation and entrepreneurship environment could lessen this negative impact. However, the moderating role of innovation and entrepreneurship environment is only relevant in terms of the quantity of firm innovation outcome (but not the quality of innovation outcome) and firms which are non-high-tech or financially constrained. These results still hold after various robustness checks.

The policy implications are manifold. First, local governments should establish effective long-term mechanisms to ensure policy continuity during political turnover. Political turnover may lead to changes in government policies (Pertuze et al., 2019) and hence can disrupt ties between local businesses and the government (Fang et al., 2023). Although firms can adapt to different policies, policy uncertainty hinders their adaptability (Bhattacharya et al., 2017) and can reduce firms' innovation efficiency (Zhou et al., 2023). Therefore, effective long-term mechanisms should be established to create a stable and predictable policy environment and enhance the predictability of government actions to ensure policy continuity and stability after local political changes. These mechanisms can help create an atmosphere of policy stability and are crucial to maintain firms' innovation efficiency (Zhou et al., 2023). In addition, policymakers need to quickly disseminate information about public policies to the market so that the adverse effects of policy uncertainty can be minimized (William & Fengrong, 2022).

Second, local governments should fully explore the benefits of the innovation and entrepreneurship environment and design pertinent policy systems according to firms' characteristics. Regional innovation and entrepreneurship environment is an essential determinant of innovation (Dubina et al., 2017). However, optimizing the innovation and entrepreneurship environment is a long-term and complex process, and local officials generally lack incentives to implement long-term development policies due to their limited

^④ The "unit area score" index takes into consideration of the land area of a prefecture-level city.

^⑤ We also used the nbreg model. The estimation results still support hypotheses H1 and H2. Due to the limitation of space, the above estimation results are not shown in this paper and are kept for reference.

Table 9
Results of robustness checks.

	Replacing dependent variables		Replacing independent variable		Replacing moderating variable		Replacing estimation model		Removing the 2012 sample	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<i>gt</i>	<i>innovnum</i> -0.0428* (-1.9225)	<i>innovqua</i> -0.0666* (-1.8746)	<i>innovnum</i> -0.0552** (-2.1490)	<i>innovqua</i> -0.0624* (-1.8144)	<i>innovnum</i> -0.0674*** (-2.6383)	<i>innovqua</i> -0.0766** (-2.1249)	<i>innovnum</i> -0.0355*** (-2.8056)	<i>innovqua</i> -0.0382 (-1.5889)	<i>innovnum</i> -0.0636** (-2.4629)	<i>innovqua</i> -0.0769** (-2.0535)
<i>index</i>	0.1661*** (2.8502)	0.1265 (1.5065)	0.1140* (1.6942)	0.1362 (1.5438)	0.4612*** (2.8525)	0.2764 (1.4075)	0.0407 (1.2103)	0.1084* (1.9400)	0.1331* (1.9320)	0.1260 (1.4061)
<i>gt_index</i>	0.0381* (1.6703)	0.0196 (0.5021)	0.0507** (2.3666)	-0.0048 (-0.1452)	0.0515** (2.0569)	0.0197 (0.4916)	0.0251** (2.0139)	0.0318 (1.1028)	0.0690*** (2.6510)	0.0293 (0.7042)
<i>Constant</i>	-9.0024*** (-6.1172)	-3.6062** (-1.9979)	-10.0398*** (-7.2445)	-3.6679** (-2.0223)	-10.0347*** (-7.3064)	-3.6786** (-2.0213)	-3.4137*** (-5.0475)	-6.3754*** (-4.6406)	-9.9541*** (-7.2086)	-3.6768* (-1.9300)
N	4360	4360	4360	4360	4360	4360	3902	3480	3946	3946
R ²	0.3104	0.3907	0.3056	0.3948	0.3076	0.3950	0.2643	0.3344	0.3234	0.3974

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

tenure in office (Wu, 2017). This phenomenon contradicts the long-cycle characteristics of high-level and high-quality innovation activities that need long-term strategies and investment. Therefore, regular performance appraisals of local officials should reflect high-quality innovation activities and outcomes, as a sound performance appraisal system for cadres can control the short-sighted behaviour of government officials to some extent (Jiang et al., 2020).

Declaration of Competing Interest

None

Data availability

Data will be made available on request.

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Appendix

Table A1
Sample distribution.

Year	Observations before screening	Observation after screening	The proportion of total sample (%)
2008	1602	413	9.47 %
2009	1751	417	9.56 %
2010	2106	418	9.59 %
2011	2341	415	9.52 %
2012	2472	414	9.50 %
2013	2515	407	9.33 %
2014	2631	389	8.92 %
2015	2823	381	8.74 %
2016	3130	385	8.83 %
2017	3506	393	9.01 %
2018	3602	328	7.52 %
Total	28479	4360	100 %

Table A2
Results of testing exclusion restriction variables.

	(1) <i>innovnum</i>	(2) <i>innovqua</i>
<i>Tenure</i>	0.0066 (0.7779)	0.0048 (0.3930)
<i>Age</i>	-0.0025 (-0.4591)	0.0068 (1.0147)
<i>Constant</i>	-10.0639*** (-7.1284)	-4.0897** (-2.1689)
N	4360	4360
R ²	0.3028	0.3937

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

Table A3
Results of testing exogeneity.

	(1) <i>innovnum</i>	(2) <i>innovqua</i>	(3) <i>innovnum</i>	(4) <i>innovqua</i>	(5) <i>innovnum</i>	(6) <i>innovqua</i>	(7) <i>innovnum</i>	(8) <i>innovqua</i>
<i>gt</i>	-0.0620**	-0.0720**	-0.0616**	-0.0715**	-0.0657***	-0.0735**	-0.0636**	-0.0723**

(continued on next page)

Table A3 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	innovnum	innovqua	innovnum	innovqua	innovnum	innovqua	innovnum	innovqua
<i>index</i>	(-2.3681)	(-2.0474)	(-2.3704)	(-2.0362)	(-2.6164)	(-2.1373)	(-2.6011)	(-2.1468)
			0.1376**	0.1382				
			(2.0164)	(1.5510)				
<i>index_iv</i>	0.1185*	0.0424	0.0908	0.0146				
	(1.7248)	(0.4093)	(1.3233)	(0.1345)				
<i>gt_index</i>							0.0709**	0.0383
							(2.0560)	(0.8448)
<i>gt_index_iv</i>					0.0640**	0.0285	0.0163	0.0027
					(2.2872)	(0.7754)	(0.4431)	(0.0665)
<i>imr</i>	0.0520	0.0392	0.0510	0.0382	0.0604	0.0430	0.0573	0.0413
	(1.0518)	(0.5692)	(1.0342)	(0.5546)	(1.1951)	(0.6250)	(1.1409)	(0.6015)
<i>Constant</i>	-10.1910***	-3.8321**	-10.1340***	-3.7749**	-10.2036***	-3.8287**	-10.2157***	-3.8342**
	(-7.2790)	(-2.0691)	(-7.2330)	(-2.0428)	(-7.2270)	(-2.0804)	(-7.2492)	(-2.0827)
<i>N</i>	4288	4288	4288	4288	4288	4288	4288	4288
<i>R</i> ²	0.3081	0.3980	0.3093	0.3988	0.3083	0.3981	0.3091	0.3982

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

Table A4

Results of testing hypothesis 3a (IV method).

	High financial constraints				Low financial constraints			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>
<i>gt</i>	-0.0828**	-0.1163***	-0.0810**	-0.1089***	-0.0465	-0.0515	-0.0529	-0.0510
	(-2.3631)	(-2.6005)	(-2.4330)	(-2.5933)	(-1.2860)	(-1.1248)	(-1.4714)	(-1.0793)
<i>index</i>	0.6374	-0.2134	0.6213	-0.2778	0.3742	0.1330	0.3133	0.1380
	(1.5818)	(-0.3537)	(1.4891)	(-0.4572)	(0.6383)	(0.1824)	(0.5308)	(0.1884)
<i>gt_index</i>			0.0261	0.1045			0.1223**	-0.0102
			(0.4298)	(1.2573)			(2.3162)	(-0.1271)
<i>imr</i>	0.1583**	0.2152***	0.1587**	0.2169***	0.0659	0.0558	0.0764	0.0549
	(2.4712)	(2.9955)	(2.4587)	(3.0288)	(0.8331)	(0.4925)	(0.9640)	(0.4831)
<i>N</i>	2081	2081	2081	2081	2179	2179	2179	2179
<i>R</i> ²	0.3092	0.4140	0.3108	0.4133	0.3282	0.4226	0.3281	0.4226
Kleibergen-Paap rk LM statistic	8.14***	8.14***	8.14***	8.14***	8.53***	8.53***	8.53***	8.53***
Cragg-Donald Wald F statistic	67.77	67.77	67.77	67.77	45.67	45.67	45.67	45.67
FAR statistic-P value	0.3383	0.3542	0.3755	0.3952	0.3184	0.3247	0.3517	0.3632

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

Table A5

Results of testing hypothesis 3b (IV method).

	High-tech				Non-high-tech			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>
<i>gt</i>	-0.0399	-0.0520	-0.0357	-0.0510	-0.0857**	-0.0750*	-0.0896***	-0.0783*
	(-1.0850)	(-0.9553)	(-1.0116)	(-0.9643)	(-2.3523)	(-1.6979)	(-2.5998)	(-1.7933)
<i>index</i>	0.7047	-0.6016	0.6604	-0.6122	0.1263	1.1708	0.0628	1.1182
	(1.5252)	(-0.9183)	(1.3740)	(-0.9352)	(0.2493)	(1.4952)	(0.1243)	(1.4193)
<i>gt_index</i>			0.0723	0.0173			0.1120**	0.0929
			(1.3864)	(0.1990)			(2.1471)	(1.2957)
<i>imr</i>	0.1066	0.1746	0.1063	0.1745	0.0364	-0.0213	0.0452	-0.0139
	(1.1884)	(1.3260)	(1.1921)	(1.3225)	(0.6119)	(-0.2944)	(0.7282)	(-0.1952)
<i>N</i>	1772	1772	1772	1772	2499	2499	2499	2499
<i>R</i> ²	0.3058	0.4524	0.3074	0.4520	0.2859	0.2886	0.2886	0.2912
Kleibergen-Paap rk LM statistic	8.28***	8.28***	8.28***	8.28***	7.09***	7.09***	7.09***	7.09***
Cragg-Donald Wald F statistic	75.96	75.96	75.96	75.96	35.33	35.33	35.33	35.33
FAR statistic-P value	0.3157	0.3775	0.3414	0.4243	0.2805	0.2596	0.3013	0.2775

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

Table A6
Results of replacing moderating variable.

	Marketization Index		Urban Innovation Index	
	(1)	(2)	(3)	(4)
	<i>innovnum</i>	<i>innovqua</i>	<i>innovnum</i>	<i>innovqua</i>
<i>gt</i>	-0.0727*** (-2.7034)	-0.0755** (-2.0247)	-0.0684*** (-2.6561)	-0.0724* (-1.9671)
<i>index</i>	-0.0353 (-0.4119)	-0.1926* (-1.7036)	-0.0569* (-1.9613)	-0.0890** (-2.0623)
<i>gt_index</i>	0.0440* (1.6808)	0.0221 (0.8175)	0.0395** (2.1444)	0.0221 (1.0615)
<i>Constant</i>	-10.1233*** (-7.2616)	-3.8935** (-2.1565)	-10.1677*** (-7.3175)	-3.8008** (-2.1025)
N	4360	4360	4360	4360
R ²	0.3042	0.3955	0.3044	0.3954

Note: All regressions include the same set of control variables as those in Table 3, and firm fixed effects and year-industry fixed effects.

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