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State Ownership Heterogeneity and Corporate Innovation: New Evidence from a Hierarchical Perspective

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Abstract

Unlike prior research, this study re-examines the relationship between state ownership and corporate innovation from a hierarchical perspective. Drawing upon institutional theory, our findings reveal the heterogeneous impact of state ownership, elucidating the positive role of central state ownership in fostering corporate innovation, while highlighting the inhibitory effect of local state ownership. This conclusion withstands rigorous scrutiny through a battery of robustness checks. Mechanism analysis indicates that central state-owned enterprises stimulate innovation by increasing innovation investment and enhancing efficiency, whereas local state-owned enterprises create obstacles for both innovation investment and efficiency. Our paper offers a hierarchical interpretation of the mixed evidence regarding the relationship between state ownership and corporate innovation. Whether state ownership serves as a facilitator or a hindrance to innovation depends on whether central or local state-owned enterprises dominate the national innovation process. Overall, this study offers new insights into the complex effects of state ownership heterogeneity on corporate innovation activities in emerging economies like China, advancing our understanding of the subtle relationship between corporate governance and innovation.

Keywords: state ownership heterogeneity, corporate innovation, central state ownership, local state ownership, institutional theory, China

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Introduction

Corporate innovation plays a key role in economic growth and enhances competitive advantage [1]. However, due to high institutional divergence, many emerging countries are not easily described by models established in developed countries [2]. For instance, state ownership in China is controlled by the central and local levels of government (Figure 1), so whether different hierarchies of state ownership have different impacts on corporate innovation remains an unsolved puzzle.

Existing literature suggests that state ownership may be a potential factor influencing a firm's innovation activities [2–4]. However, the understanding of how state ownership affects corporate innovation remains limited and marked by conflicting findings. For example, J. Yi et al. [5] assert that state-owned enterprises (SOEs) exhibit a proactive stance in innovation, insofar as governments, as shareholders, exert institutional pressures mandating compliance with regulations and alignment with government objectives [3; 6]. They argue that the efficiency and innovation potential of firms hinge significantly on the quality of the institutional framework [7]. In contrast, H. Kou and K. Kroll [8] establish a negative relationship between state ownership and corporate innovation, attributing this to self-interest-driven SOE managers pursuing goals misaligned with corporate performance [9]. Unless robust corporate governance mechanisms are in place, rent-seeking behaviours prevail in SOEs [10].

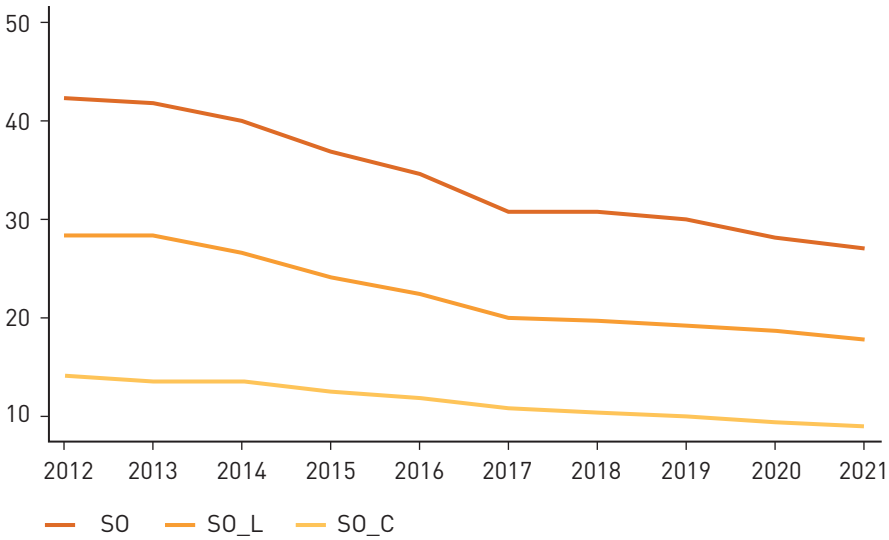
These mixed results may overlook the hierarchical dynamics within SOEs. Specifically, institutional pressures and innovation incentives vary between central and local SOEs. Central SOEs operate under the control of the central government [11]. The central government is responsible for setting and allocating tasks for central SOEs, with long-term sustainable economic growth strategy being a key objective [12]. In contrast, local governments have shorter evaluation periods for performance and heavily rely on quantifiable performance indicators [8; 12]. Therefore, they often lean towards short-term economic growth strategies, while local SOE managers are more inclined to seek promotion rewards within the local political ladder and thus consistency with the local government.

Utilizing data from Chinese listed firms spanning the period 2012–2021, this study employs separate dummy variables to delineate the hierarchy of SOEs at the central and local levels. We provide compelling evidence that the inclination towards innovation is stratified by state ownership: central SOEs tend to foster innovation, whereas local SOEs tend to impede it. In the mechanism analysis, local SOEs hamper innovation by curtailing R&D investment and diminishing innovation efficiency, while central SOEs stimulate innovation primarily by facilitating increased R&D investment and improving innovation efficiency.

Our study makes several contributions. First, we trace how the different hierarchies of state ownership relate to corporate innovation, which goes beyond previous research that focused solely on the relationship between total state ownership and corporate innovation [2; 3; 5]. By examining the nonconformity between the influence of evaluation mechanisms and the hierarchical structure of state-owned enterprises, we can gain a better understanding of how state ownership heterogeneity influences innovation activities.

Second, our research contributes to the ongoing debate on the relationship between state ownership and corporate innovation. Previous studies have yielded mixed results on this issue, partly due to a lack of understanding of the heterogeneity of state ownership. By dividing state ownership into central and local categories, this study innovatively explains the discrepancies observed in prior studies, offering a comprehensive perspective from different levels of state ownership.

Figure 1. Percentage of state-controlled entities among Chinese A-share listed firms (2012–2021)



Note: SO, SO_C, and SO_L refer, respectively, to the percentage of firms ultimately controlled by total government entities, central government entities, and local government entities.

Source: prepared by authors.

Third, the design of government systems emerges as a pivotal factor for both transition countries and developing markets [13]. Previous research has seldom addressed the differences in the propensity to innovate between central and local SOEs from an institutional perspective. This study offers new insights in this domain, serving as an essential reference for developing countries aspiring to emulate the Chinese innovation system and transition towards an innovative economy.

The subsequent sections unfold as follows: the second part describes the theoretical foundations and hypothesis development; the third part sets out the study methodology; the fourth part analyses findings, makes robustness checks and further studies the influence mechanism; and the final part summarizes the conclusions.

Theoretical Foundations and Hypothesis Development

Institutional Theory

Institutional theory focuses on the interactions between institutions and organisations, emphasising that the behaviour of a firm is significantly shaped by the institutional environment in which it operates [14; 15]. Such institutions consist of societal, economic, and political organizations, as well as informal social norms and rules [5; 7]. Companies must adjust to diverse institutional constraints to obtain essential resources and support due to institutional pressures [16; 17].

Owing to path dependence, one of the noticeable aspects of Chinese SOEs is extensive government intervention, which comprises ownership control and personnel management systems [18; 19]. It is widely believed that SOEs enjoy privileges granted by the government and related agencies. According to Y. Liu et al. [20], SOEs in emerging markets often obtain financial support and other resources from the government. Nonetheless, the connection between government and state ownership results in institutional pressures that force SOEs to use resources in accordance with government-set public objectives, for instance, economic growth and national innovation strategies [17; 19].

Hypothesis Development

In emerging markets, distinctive institutional factors wield considerable influence over a firm's impetus and capacity for innovation investment [21; 22]. Within the framework of institutional theory, the role of ownership in corporate governance necessitates the consideration of institutional factors [9; 16]. The process of corporate innovation is perceived as the dynamic accumulation of learning and innovation, intricately entwined with the national economic structure and institutional milieu [23]. Within this trajectory, corporate conduct is frequently moulded by prevailing organisational norms and rules [14].

Diverging from most developed countries, the managerial cadre of Chinese state-owned enterprises (SOEs) typically comprises bureaucrats rather than entrepreneurs [24; 25]. This unique group bears a resemblance to formal government officials [5; 10; 16]. Significantly, within the Chinese institutional context, the evaluation mechanisms of central SOEs and local SOEs exhibit heterogeneity. Central government departments oversee central SOEs, whereas local governments, as the de facto controllers of local SOEs, dictate personnel decisions – such as appointments, transfers, and dismissals of top executives – bypassing market-oriented processes [5; 11].

Prior investigations have affirmed that managers of state-owned enterprises, serving as agents of government shareholders, are driven by political motivations to secure promotions to higher positions [26]. This political motivation transcends mere monetary compensation considerations [27]. However, the hierarchy of state ownership engenders substantial divergence in the political objectives of SOEs. The central government in China is inclined toward adopting long-term strategies to foster innovation and industrial upgrading, aiming to bolster the international competitiveness of Chinese firms. For instance, the 2006 "National Medium and Long-Term Program for Science and Technology Development (2006–2020)" outlined a 15-year government-led strategy for technological innovation, incorporating innovation subsidies, information, and technological support, as well as tax reductions and policy incentives linked to technology. Consequently, potential political motivations impel central SOEs to augment research and development (R&D) investments. Simultaneously, subsidies, tax reductions, and policy incentives hinge largely on firms' innovation achievements, intensifying the impetus for corporate innovation [28]. These advantages also streamline the firms' innovation processes, consequently enhancing innovation efficiency. Hence, central state ownership profoundly fosters corporate innovation, particularly through heightened inputs and efficiency.

Conversely, the advancement of local government officials predominantly hinges on short-term economic growth within their regions and individual accomplishments. The divergence in political objectives underscores substantial disparities in the strategic approach to corporate innovation between central and local SOEs. Given the proclivity of local governments toward GDP-centric goals, they are more prone to steer state-owned enterprises toward investing in fixed assets, concurrently curbing long-term R&D investments fraught with greater uncertainty and higher failure rates [16; 25]. Guided by these policies, SOE managers are predisposed to adopt shorter-term investment strategies in the competitive landscape [8], thereby diminishing the impetus for corporate innovation and R&D expenditures and ultimately reducing the innovation efficiency of local SOEs. Consequently, the inhibitory impact of local state ownership on corporate innovation is more pronounced. Based on the foregoing arguments, we posit the following hypothesis:

H1. The impact of state ownership is hierarchical: central state ownership promotes corporate innovation, while local state ownership inhibits corporate innovation.

Methods

Sample and Data

This study collected ownership and financial data for all Chinese A-share listed firms from the CSMAR database spanning the years 2012–2021, while patent information was sourced from the CNRDS database. We meticulously cross-checked firm data with annual reports and official websites, adhering to the data pre-processing protocols articulated by R. Yuan and W. Wen [29]. First, financial firms (e.g., banks, insurance firms, and mutual funds) were excluded due to their distinctive governance and performance systems compared to non-financial Chinese firms. Second, "special treatment" firms – those experiencing continuous losses for two consecutive years and facing the risk of delisting – were omitted to mitigate the impact of abnormal financial conditions. Third, observations with missing information were discarded to minimize the influence of incomplete data on the results. Last, to further mitigate the impact of outliers, all continuous variables underwent winsorization at the 1st and 99th percentiles.

Variable Measurement and Model Specification

The dependent variables in this study measure corporate innovation (Patent_apply, Patent_grante, and Patent_citation). The measurement method utilizes patent data provided by the CNRDS database. This database serves as a professional source for patent data analysis, covering multiple measurements and patent information, and has been widely accepted in the field. Following prior studies (e.g., R. Yuan, W. Wen; N. Ding et al. [29; 30]), the first measure, Patents_ apply, is the natural logarithm of a firm's total patent applications plus one, including invention patents, design patents, and utility patents. The second, Patents_ grante, is the natural logarithm of a firm's total granted patents plus one. The third, Patent_ citation, represents the natural logarithm of a firm's total patent citation counts plus one.

The independent variables used in this study are state ownership (SO) and its heterogeneous sub-variables – central state ownership (SO_C) and local state ownership (SO_L). In China, the prevalent phenomenon of cross-ownership and pyramidal control has been longstanding. The government often exercises indirect control over a specific enterprise by holding shares in other companies and implementing a hierarchical ownership structure within corporate groups. This intricate ownership framework complicates the calculation of the percentage of state ownership, as the extent of control may not be fully reflected in the direct shareholding percentage. Consequently, there is a risk of underestimating the control exerted by state-owned enterprises when computing ownership percentages, given that their influence may well extend beyond the direct ownership figures. To address this, inspired by P. Pessarossi and L. Weill [31] and N. Lin et al. [32], a dummy variable is employed to indicate state ownership (1 for state-owned entities and 0 otherwise). The two heterogeneous sub-variables are central state ownership (SO_C) and local state ownership (SO_L). SO_C is a dummy variable equal to 1 for central state-owned entities and 0 otherwise, while SO_L is a dummy variable equal to 1 for local state-owned entities and 0 otherwise.

Furthermore, the study incorporates several control factors potentially affecting corporate innovation, aligning with prior research (e.g., R. McGuinness et al.; R. Yuan, W. Wen; N. Jia et al.; D. Kong et al.; N. Ding et al.; G. Liu, L. Lv [19; 29; 30; 33–35]). These include Firm Size (logarithm of total assets), Firm Age (natural logarithm of years since establishment plus one), Return on Assets (net income divided by total assets), Financial Leverage (total debts divided by total assets), Sale Growth (ratio of changed operating income to last year's operating income), Cash Ratio (cash holdings divided by total assets), Board Size (natural logarithm of total board directors), Ownership Concentration (percentage of shares owned by the largest shareholder), and Institutional Ownership (shares held by institutional investors divided by total shares). Refer to Table 1 for variable details and measurements.

To mitigate potential endogeneity, following previous studies (e.g., J. He, X. Tian; R. Yuan, W. Wen [29; 36]), we employ an OLS model and regress contemporaneous innovation measures on one-year lagged values of state ownership and other explanatory variables. The basic empirical model is as follows:

$$Patent\_apply_{i,t+1} = \alpha_0 + \alpha_1 SO_{i,t} + \alpha_2 FS_{i,t} + \alpha_3 FA_{i,t} + \\ + \alpha_4 ROA_{i,t} + \alpha_5 LEV_{i,t} + \alpha_6 SG_{i,t} + \alpha_7 CR_{i,t} + \alpha_8 BS_{i,t} + \\ + \alpha_9 OC_{i,t} + \alpha_{10} IO_{i,t} + Year + Industry + \varepsilon, \quad (1)$$

where α_0 denotes the intercept, and $\alpha_1 - \alpha_{10}$ are the coefficients to be estimated. This study added dummy variables that control for year and industry fixed effects (Year and Industry); ε is the error term; i denotes the cross-sectional dimension for firms; and t denotes the time series dimension.

Table 1. Summary of Variable Descriptions and Measurements

	Measurement
Panel A: Dependent Variables	
Patent_ apply	The natural logarithm of the firm's total patent applications plus one.
Patent_grante	The natural logarithm of the firm's total granted patents plus one.
Patent_ citation	The natural logarithm of the firm's total patent citation counts plus one.
Panel B: Independent Variables	
State Ownership (SO)	A dummy variable which equals 1 if the firm is a state-owned entity and 0 otherwise.

	Measurement
Central State Ownership (SO_C)	A dummy variable which equals 1 if the firm is a central state-owned entity and 0 otherwise.
Local State Ownership (SO_L)	A dummy variable which equals 1 if the firm is a local state-owned entity and 0 otherwise.
Panel C: Control Variables	
Firm Size (FS)	The logarithm of total assets.
Firm Age (FA)	The natural logarithm of the number of years since the firm's establishment plus one.
Return on Assets (ROA)	The book value of net income divided by total assets.
Financial Leverage (LEV)	The book value of total debts divided by total assets.
Sale Growth (SG)	The ratio of the changed operating income to the operating income in the last year.
Cash Ratio (CR)	The book value of cash holdings divided by the book value of total assets.
Board Size (BS)	The natural logarithm of the total number of directors on the firm's board.
Ownership Concentration (OC)	The percentage of shares owned by the largest shareholder.
Institutional Ownership (IO)	The number of shares held by institutional investors divided by the total shares.
Panel D: Other Variables	
Research and Development Expenditure (R&D)	The ratio of R&D expenditure to total assets.
Innovation Efficiency (IE)	Number of patent applications per unit of R&D input.

Source: prepared by authors.

Findings and Discussion

Descriptive Statistics and Correlation Matrix

The descriptive statistics for the key variables in our study are presented in Table 2, including the mean, standard deviation, minimum, and maximum values. For Patent_apply, the mean and standard deviation are 2.622 and 1.721; for Patent_grante, 2.451 and 1.643; and, for Patent_citation, 1.959 and 1.803, respectively. These values reveal slight variations in innovation measures among the sampled firms. On average, 32.9% of firm-year observations pertain to state-owned entities, with central state ownership (local state ownership) accounting for 11.2% (21.7%). This confirms the existence of state ownership heterogeneity.

Regarding control variables, the sample firms exhibit an average Firm Size of 22.200, Firm Age of 2.908, ROA of 0.041, Financial Leverage of 0.412, Sale Growth of 0.169, Cash Ratio of 0.049, Board Size of 2.120, Ownership Concentration of 34.383, and Institutional Ownership of 44.234. Additionally, R&D is 0.021, and Innovation Efficiency is 0.140.

Table 3 displays the Pearson correlation matrix for the major variables. The correlation coefficients between the explanatory and control variables are mostly below 0.50. Furthermore, we conducted a multicollinearity diagnostic test among the continuous variables. Each control variable exhibits a low variance inflation factor (VIF) in the test (less than 2), indicating the absence of multicollinearity issues in our model.

Univariate Analysis

Table 4 presents the findings of univariate tests conducted on the dependent variable in our study. The mean of Patent_apply is 3.241 for firms classified as central state-owned entities and 2.544 for those not falling under central state ownership. These differences are statistically significant at the 1% level, indicating that firms classified as central state-owned entities exhibit higher levels of innovation output compared to their counterparts.

Conversely, being categorized as a local state-owned entity significantly diminishes innovation output (Differences T-value = –0.477; P-values < 0.01). The negative t-statistics for the mean differences, coupled with a 1% significance level, confirm the statistical significance of these variations based on whether the firm is a local state-owned entity. In summary, these outcomes lend initial support to Hypothesis 1, suggesting that central state ownership fosters corporate innovation, while local state ownership hampers it.

Multivariate Results

The results of the OLS models are presented in Table 5, where the dependent variable is corporate innovation (Patent_apply). H1 is supported by the positive or negative coefficients and significance level in the regressions of SO_C and SO_L. Specifically, the coefficient of SO_C in Column (2) is 0.265, significant at the 1% level, indicating that

central state ownership promotes corporate innovation. However, the coefficient of SO_L in Column (3) is –0.072, significant at the 1% level, suggesting that local state ownership inhibits corporate innovation. Additionally, to examine whether the impact of total state ownership (SO) on corporate innovation is driven by central state ownership or local state ownership, Column (1) tests the relationship between SO and Patent_apply. The coefficient of SO is significant at the 1% level (α = 0.105), indicating that state ownership has a significantly positive overall effect on corporate innovation.

The aforementioned findings suggest that the relationship between state ownership and corporate innovation is hierarchical, with central state ownership promoting innovation and local state ownership inhibiting it. This provides a new explanation for the mixed evidence on the relationship between state ownership and corporate innovation (e.g., K. Kroll, H. Kroll; Y. Liu et al. [8; 20]), indicating that whether state ownership promotes or inhibits corporate innovation depends on whether central or local state ownership predominates in the innovation process.

Furthermore, the signs of the control variables are consistent with previous literature (e.g., Q. Hou et al.; K. Kroll, H. Kroll; R. Zhang et al. [8; 17; 37]). The results demonstrate that firm size, return on assets, and board size are positively and significantly related to Patent_apply in all columns, while firm age and financial leverage exhibit negative relationships with Patent_apply in all columns. Institutional ownership, however, is only negatively and significantly related to Patent_apply in Column (2). Sales growth, cash ratio, and ownership concentration are not significant with Patent_apply.

Table 2. Descriptive Statistics

Variables	N	Mean	Std	Min	Max
Patent_apply	29 108	2.622	1.721	0.000	6.690
Patent_grante	29 108	2.451	1.643	0.000	6.409
Patent_citation	29 108	1.959	1.803	0.000	7.014
SO	29 108	0.329	0.470	0.000	1.000
SO_C	29 108	0.112	0.315	0.000	1.000
SO_L	29 108	0.217	0.412	0.000	1.000
FS	29 094	22.200	1.296	19.814	26.153
FA	29 094	2.908	0.325	1.609	3.497
ROA	27 239	0.041	0.063	–0.239	0.222
LEV	29 094	0.412	0.204	0.050	0.893
SG	27 234	0.169	0.390	–0.544	2.445
CR	29 094	0.049	0.067	–0.159	0.241
BS	29 053	2.120	0.197	1.609	2.708
OC	29 056	34.383	14.817	8.630	74.180
IO	29 025	44.234	25.232	0.321	94.529
R&D	29 108	0.021	0.020	0.000	0.101
IE	29 108	0.140	0.093	0.000	0.332

Source: calculated by authors.

Table 3. Pearson Correlation

	Patent_apply	SO	FS	FA	ROA	LEV	SG	CR	BS	OC	IO	VIF
Patent_apply	1.000											-
SO	–0.008	1.000										1.41
FS	0.293***	0.385***	1.000									1.78
FA	–0.036***	0.206***	0.183***	1.000								1.09
ROA	0.076***	–0.117***	–0.003	–0.080***	1.000							1.55
LEV	0.081***	0.309***	0.533***	0.178***	–0.358***	1.000						1.71
SG	0.027***	–0.088***	0.037***	–0.043***	0.259***	0.021***	1.000					1.11
CR	0.052***	–0.017***	0.064***	0.004	0.411***	–0.169***	0.026***	1.000				1.24
BS	0.046***	0.277***	0.274***	0.057***	–0.003	0.156***	–0.024***	0.036***	1.000			1.14
OC	–0.006	0.210***	0.186***	–0.084***	0.127***	0.051***	–0.010*	0.102***	0.017***	1.000		1.39
IO	0.045***	0.415***	0.440***	0.053***	0.102***	0.208***	0.028***	0.119***	0.230***	0.485***	1.000	1.78

Note. This table shows the correlation coefficients for the main variables defined in Table 1. The lower triangle in this table shows the Pearson correlation coefficients. VIF indicates the variance inflation factor. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, respectively.
Source: calculated by authors.

Table 4. Univariate Analysis

	Dummy (CSO) = 1		Dummy (CSO) = 0		Differences	Dummy (LSO) = 1		Dummy (LSO)=0		Differences
	N	Mean	N	Mean	T-value	N	Mean	N	Mean	T-value
Patent_apply	3256	3.241	25852	2.544	0.697***	6321	2.249	22787	2.725	-0.477***

Note. This table presents the results of univariate analysis on the mean difference of the corporate innovation indicator Patent_apply between "the firm is a central (local) state-owned entity" and "the firm is not a central (local) state-owned entity". The t-values for the mean differences are based on t-tests. ***denotes significance at the 1% level.

Source: calculated by authors.

Table 5. Multivariate Results

	Patent_apply $_{(t+1)}$		
	(1)	(2)	(3)
SO	0.105***		
	(0.02)		
SO_C		0.265***	
		(0.03)	
SO_L			−0.072***
			(0.02)
FS	0.623***	0.625***	0.633***
	(0.01)	(0.01)	(0.01)
FA	−0.217***	−0.201***	−0.177***
	(0.03)	(0.03)	(0.03)
ROA	2.113***	2.172***	2.104***
	(0.18)	(0.18)	(0.18)
LEV	−0.158***	−0.125**	−0.106*
	(0.06)	(0.06)	(0.06)
SG	0.001	−0.004	−0.015
	(0.03)	(0.03)	(0.03)
CR	0.169	0.130	0.099
	(0.15)	(0.15)	(0.15)
BS	0.206***	0.198***	0.231***
	(0.05)	(0.05)	(0.05)
OC	−0.001	−0.001	−0.000
	(0.00)	(0.00)	(0.00)
IO	−0.000	−0.001*	−0.000
	(0.00)	(0.00)	(0.00)
Cons	−10.975***	−11.034***	−11.368***
	(0.23)	(0.22)	(0.22)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	22 935	22 935	22 935
Adj. R^2	0.493	0.495	0.493

Note. This table presents the baseline result of the impact of state ownership heterogeneity on corporate innovation. The dependent variable is Patent_apply, while the independent variables are total state ownership (SO), central state ownership (SO_C) and local state ownership (SO_L). All regressions include year fixed effects and industry fixed effects. Parentheses show robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, respectively. All variables are defined in Table 1.

Source: calculated by authors.

Robustness Check

Thus far, the estimations reveal a nuanced relationship between state ownership and corporate innovation. We employ various methods in this section to ensure the robustness of our results.

First, alternative dependent variables. To address concerns regarding potential measurement errors, following D. Kong et al. [33] and N. Ding et al. [30], we introduce two alternative dependent variables: the natural logarithm of the total number of patents granted to a firm plus one (Patent_grante) and the natural logarithm of the number of patent citations received by a firm plus one (Patent_citation). Unlike the past reliance on the number of patent applications as an innovation indicator, the number of granted patents represents the actual quantity recognized and certified by governmental intellectual property agencies. Patent citations provide a quality-oriented perspective on innovation activity [30]. Panel A of Table 6 presents the robustness test results based on these two alternative dependent variables. The estimated coefficients of the primary variables exhibit similar magnitudes and directions as shown in Table 6, confirming the robustness of the baseline regression.

Second, two subsample tests. Addressing the argument by R. Zhang et al. [17] that firms in high-tech industries may have distinctive innovation needs, this study re-evaluates primary models using two different subsamples: one composed of high-tech industry firms and the other consisting of non-high-tech industry firms. Results in Panel B of Table 7 demonstrate that both SO and SO_C have a significantly positive influence on corporate innovation in both high-tech and non-high-tech industries. However, SO_L continues to exhibit a negative impact on corporate innovation at the 1% significance level within this subset. These results are in line with previous findings, confirming the consistency of our conclusions.

Third, alternative estimation methods. Considering the count nature of patents, R. Zhang et al. [17] suggest that fixed-effect model estimation might be misleading even with the logarithmic transformation of patent data. Therefore, this section employs the maximum likelihood method to estimate the Poisson regression model in Panel C of Table 8. Additionally, inspired by H. Kim et al. [38] to address truncation in patent data, the Tobit regression model is introduced. The results from both the Poisson model and the Tobit model (cf. Table 8) align with conclusions drawn in the previous main regression model.

Fourth, correcting for selection bias with the Heckman two-step selection model. Since the propensity of different SOEs to apply for patents may be non-random, causing self-selection bias, following R. Zhang et al. [16], the first stage estimates a probit model with a binary dummy (Dummy_Patent) as the dependent variable, equal to 1 if a firm has ever applied for a patent and 0 otherwise. The following probit model is used to estimate the probability of firms applying for patents:

$$Probit\left(Dummy\_Patent\right)_{i,t} = \alpha_0 + \alpha_1 FS_{i,t} + \alpha_2 FA_{i,t} + \\ + \alpha_3 ROA_{i,t} + \alpha_4 LEV_{i,t} + \alpha_5 SG_{i,t} + \alpha_6 CR_{i,t} + \alpha_7 BS_{i,t} + \\ + \alpha_8 OC_{i,t} + \alpha_9 IO_{i,t} + Year + Industry + \varepsilon. \quad (2)$$

The inverse Mills ratio (IMR) is then obtained from this probability and included in the second stage regression. The results in Panel D of Table 9, after correcting for selection bias, indicate that the estimated coefficients of SO, SO_C, and SO_L consistently maintain the same signs as the previous ones and remain statistically significant. Thus, potential selection bias does not compromise our main findings.

Fifth, the application of a two-stage Data Envelopment Analysis model to control for managerial ability. Recognizing the pivotal role of managers in corporate innovation, differences in their ability levels can significantly impact innovation outputs. To address these differences, following R. Yuan and W. Wen [29], we employ a two-step procedure developed by P. Demerjian et al. [39] to estimate managerial ability.

In the first step, we assess the relative corporate efficiency of peer decision units using Data Envelopment Analysis (DEA). In the second step, we separate managerial contributions from corporate efficiency because the latter encompasses both corporate-level efficiency and manager-specific efficiency. This measurement criterion has been widely applied in accounting, finance, and management research (e.g., Z. Wang et al.; R. Yuan, W. Wen [15; 29]. In Equation (1), we introduce managerial ability (MA) as a new control variable and re-conduct a regression analysis.

The results in Panel E of Table 9 demonstrate that the signs and significance levels of all independent variables (SO, SO_C, and SO_L) remain consistent with our previous conclusions, suggesting that managerial ability is unlikely to drive our research findings.

Mechanism analysis

Research and development (R&D) expenditure and innovation efficiency (IE) are two pivotal determinants influencing corporate innovation [37; 40]. On the one hand, allocating funds and resources consistently to innovation activities enables firms to acquire new knowledge and technologies (referred to as the "input channel"). On the other hand, by enhancing innovation efficiency, organizations can bolster production efficiency, reduce costs, and consequently enhance innovation output (referred to as the "efficiency channel"). This section aims to investigate whether the heterogeneity in state ownership impacts these channels differently.

This research further adapts the baseline Equation (1) by replacing the dependent variable with R&D expenditure and innovation efficiency measured according to J. Lantz, J. Sahut [41] and A. Arundel, I. Kabla [42]. Table 10 presents regression results testing the impact on the input channel and the efficiency channel separately in panels F and G, respectively. These findings reveal a hierarchical influence of state ownership on innovation inputs and efficiency in which central state ownership (SO_C) notably amplifies firm R&D expenditure and innovation efficiency, while local state ownership (SO_L) inhibits both firm R&D expenditure and innovation efficiency.

Table 6. Robustness Check (1)

	Panel A: Alternative Dependent Variables					
	Patent_grante $_{(t+1)}$			Patent_ citation $_{(t+1)}$		
	(1)	(2)	(3)	(4)	(5)	(6)
SO	0.096***			0.187***		
	(0.02)			(0.02)		
SO_C		0.243***			0.476***	
		(0.03)			(0.03)	
SO_L			−0.066***			−0.136***
			(0.02)			(0.02)
FS	0.599***	0.595***	0.603***	0.688***	0.680***	0.696***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
FA	−0.220***	−0.204***	−0.183***	−0.089***	−0.057*	−0.014
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
ROA	1.412***	1.416***	1.353***	1.078***	1.084***	0.960***
	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)
LEV	−0.103*	−0.088	−0.070	−0.403***	−0.374***	−0.337***
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)
SG	−0.021	−0.021	−0.031	−0.069***	−0.070***	−0.090***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
CR	0.278**	0.268*	0.239*	0.001	−0.018	−0.076
	(0.14)	(0.14)	(0.14)	(0.15)	(0.15)	(0.15)
BS	0.190***	0.194***	0.224***	0.097**	0.105**	0.164***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
OC	0.000	0.000	0.000	−0.003***	−0.003***	−0.003***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IO	−0.001***	−0.001***	−0.001	−0.000	−0.001	0.001*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cons	−10.576***	−10.535***	−10.841***	−12.915***	−12.834***	−13.441***
	(0.21)	(0.21)	(0.21)	(0.23)	(0.22)	(0.22)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
N	22 935	22 935	22 935	22 935	22935	22935
Adj. R^2	0.513	0.514	0.512	0.534	0.539	0.533

Note. This table presents the results of the impact of state ownership heterogeneity on corporate innovation using alternative innovation measures. The dependent variables are Patent_grante and Patent_citation, and the independent variables are total state ownership (SO), central state ownership (SO_C), and local state ownership (SO_L). All regressions include year fixed effects and industry fixed effects. Parentheses show robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, respectively. All variables are defined in Table 1.

Source: calculated by authors.

Table 7. Robustness Check (2)

	Panel B: Alternative Samples					
	High–Tech Firms			Non–High–Tech Firms		
	Patent_apply $_{(t+1)}$			Patent_apply $_{(t+1)}$		
	(1)	(2)	(3)	(4)	(5)	(6)
SO	0.094***			0.068**		
	(0.03)			(0.03)		
SO_C		0.234***			0.312***	
		(0.04)			(0.05)	
SO_L			−0.095***			−0.104***
			(0.03)			(0.03)
FS	0.677***	0.675***	0.683***	0.570***	0.561***	0.572***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
FA	−0.160***	−0.154***	−0.119***	−0.334***	−0.307***	−0.292***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
ROA	2.740***	2.742***	2.690***	1.234***	1.273***	1.160***
	(0.22)	(0.22)	(0.22)	(0.30)	(0.30)	(0.30)
LEV	0.157**	0.183**	0.214***	−0.571***	−0.576***	−0.563***
	(0.07)	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)
SG	−0.017	−0.018	−0.029	0.019	0.023	0.010
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
CR	0.446**	0.455**	0.404**	−0.108	−0.140	−0.151
	(0.20)	(0.20)	(0.20)	(0.22)	(0.22)	(0.22)
BS	0.104*	0.109*	0.150***	0.311***	0.304***	0.333***
	(0.06)	(0.06)	(0.06)	(0.08)	(0.08)	(0.08)
OC	−0.003***	−0.004***	−0.003***	0.003***	0.003***	0.004***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IO	−0.000	−0.001	0.000	−0.002**	−0.002***	−0.001*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cons	−11.567***	−11.548***	−11.911***	−10.360***	−10.200***	−10.541***
	(0.27)	(0.26)	(0.27)	(0.37)	(0.37)	(0.37)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
N	13 337	13 337	13 337	9598	9598	9598
Adj. R^2	0.428	0.430	0.428	0.447	0.449	0.447

Note. This table presents the results of the impact of state ownership heterogeneity on corporate innovation using alternative samples. The dependent variable is Patent_apply, and the independent variables are total state ownership (SO), central state ownership (SO_C), and local state ownership (SO_L). All regressions include year fixed effects and industry fixed effects. Parentheses show robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, respectively. All variables are defined in Table 1.

Source: calculated by authors.

Table 8. Robustness Check (3)

	Panel C: Alternative Estimation Methods					
	Poisson Method			Tobit Method		
	Patent_apply$_{(t+1)}$			Patent_apply$_{(t+1)}$		
	(1)	(2)	(3)	(4)	(5)	(6)
SO	0.018**			0.105***		
	(0.01)			(0.02)		
SO_C		0.076***			0.265***	
		(0.01)			(0.03)	
SO_L			−0.044***			−0.072***
			(0.01)			(0.02)
FS	0.219***	0.218***	0.221***	0.629***	0.625***	0.633***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
FA	−0.088***	−0.086***	−0.074***	−0.218***	−0.201***	−0.177***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
ROA	0.899***	0.911***	0.880***	2.169***	2.172***	2.104***
	(0.07)	(0.07)	(0.07)	(0.17)	(0.17)	(0.17)
LEV	−0.044*	−0.041*	−0.030	−0.142**	−0.125**	−0.106*
	(0.02)	(0.02)	(0.02)	(0.06)	(0.06)	(0.06)
SG	−0.001	0.000	−0.004	−0.003	−0.004	−0.015
2	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
CR	0.005	0.008	−0.009	0.142	0.130	0.099
	(0.06)	(0.06)	(0.06)	(0.14)	(0.14)	(0.14)
BS	0.103***	0.103***	0.115***	0.194***	0.198***	0.231***
	(0.02)	(0.02)	(0.02)	(0.05)	(0.05)	(0.05)
OC	0.000	0.000	0.000	−0.001	−0.001	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IO	−0.000***	−0.001***	−0.000**	−0.001	−0.001*	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cons	−3.806***	−3.769***	−3.901***	−12.444***	−12.392***	−12.692***
	(0.08)	(0.08)	(0.08)	(0.24)	(0.24)	(0.24)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
N	22 935	22 935	22 935	22 935	22935	22935
Log-likelihood	−38 795.19	−38 779.14	−38 789.57	−37 453.41	−37 419.07	−37 460.17
Wald/LR chi^2	7554.85	7705.62	7783.11	15 685.10	15 753.80	15 671.58
Pseudo R^2	0.150	0.150	0.149	0.173	0.174	0.173

Note. This table presents the results of the impact of state ownership heterogeneity on corporate innovation using alternative estimation methods. The dependent variable is Patent_apply, and the independent variables are total state ownership (SO), central state ownership (SO_C), and local state ownership (SO_L). All regressions include year fixed effects and industry fixed effects. Parentheses show robust standard errors. * p < 0.1, ** p < 0.05, *** p < 0.01, respectively. All variables are defined in Table 1.

Source: calculated by authors.

Table 9. Robustness Check (4)

	Panel D: Correcting Selection Bias			Panel E: Controlling Managerial Ability		
	Patent_apply$_{(t+1)}$			Patent_apply$_{(t+1)}$		
	(1)	(2)	(3)	(4)	(5)	(6)
SO	0.087***			0.122***		
	(0.02)			(0.02)		
SO_C		0.256***			0.282***	
		(0.03)			(0.03)	
SO_L			−0.087***			−0.057**
			(0.02)			(0.02)
FS	0.740***	0.735***	0.748***	0.574***	0.571***	0.580***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
FA	−0.290***	−0.277***	−0.254***	−0.170***	−0.149***	−0.127***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
ROA	2.319***	2.329***	2.265***	3.441***	3.435***	3.367***
	(0.18)	(0.18)	(0.18)	(0.19)	(0.19)	(0.19)
LEV	−0.243***	−0.230***	−0.212***	0.129**	0.149**	0.162***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
SG	−0.016	−0.016	−0.028	0.059**	0.058**	0.046*
	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
CR	0.057	0.049	0.012	0.261*	0.243	0.214
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
BS	0.304***	0.305***	0.343***	0.170***	0.180***	0.210***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
OC	−0.001	−0.001	−0.000	−0.000	−0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IO	−0.002***	−0.002***	−0.001**	−0.000	−0.001	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IMR	0.882***	0.883***	0.918***			
	(0.08)	(0.08)	(0.08)			
MA				−1.702***	−1.691***	−1.689***
				(0.07)	(0.07)	(0.07)
Cons	−13.763***	−13.694***	−14.140***	−10.143***	−10.137***	−10.473***
	(0.30)	(0.29)	(0.29)	(0.23)	(0.23)	(0.23)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
N	22 898	22 898	22 898	21 603	21603	21603
Adj. R^2	0.496	0.498	0.496	0.504	0.506	0.504

Note. This table presents the results of the impact of state ownership heterogeneity on corporate innovation by correcting selection bias and controlling managerial ability. The dependent variable is Patent_apply, and the independent variables are total state ownership (SO), central state ownership (SO_C), and local state ownership (SO_L). IMR denotes the inverse Mills ratio. MA denotes managerial ability. All regressions include year fixed effects and industry fixed effects. Parentheses show robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, respectively. All variables are defined in Table 1.

Source: calculated by authors.

Table 10. Mechanism Analysis

	Panel F: Input Channel R&D Expenditure		Panel G: Efficiency Channel Innovation Efficiency	
	(1)	(2)	(3)	(4)
SO_C	0.001***		0.012***	
	(0.00)		(0.00)	
SO_L		−0.001***		−0.003**
		(0.00)		(0.00)
FS	−0.001***	−0.001***	0.027***	0.027***
	(0.00)	(0.00)	(0.00)	(0.00)
FA	−0.003***	−0.003***	−0.013***	−0.012***
	(0.00)	(0.00)	(0.00)	(0.00)
ROA	0.031***	0.030***	0.101***	0.098***
	(0.00)	(0.00)	(0.01)	(0.01)
LEV	−0.002**	−0.001*	−0.007**	−0.006*
	(0.00)	(0.00)	(0.00)	(0.00)
SG	0.000	0.000	0.000	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)
CR	0.021***	0.021***	−0.004	−0.005
	(0.00)	(0.00)	(0.01)	(0.01)
BS	0.001*	0.001**	0.012***	0.014***
	(0.00)	(0.00)	(0.00)	(0.00)
OC	−0.000***	−0.000***	−0.000	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)
IO	0.000***	0.000***	−0.000**	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Cons	0.046***	0.044***	−0.442***	−0.457***
	(0.00)	(0.00)	(0.01)	(0.01)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
N	22 935	22 935	22 935	22935
Adj. R^2	0.468	0.468	0.458	0.457

Note. This table shows the regression results of the two channels through which state ownership influences corporate innovation. The dependent variables are R&D Expenditure and Innovation Efficiency, and the independent variables are central state ownership (SO_C) and local state ownership (SO_L). All regressions include year fixed effects and industry fixed effects. Parentheses show robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, respectively. All variables are defined in Table 1.

Source: calculated by authors.

Conclusion

Utilizing firm-level data spanning the period 2012–2021 in China, this study addressed the puzzle surrounding the impact of state ownership on corporate innovation, focusing on the context of Chinese SOEs. From a hierarchical perspective, our findings helped to resolve the inconsistency observed in previous research, which has been attributed to the hierarchical structure of state ownership and to differences in human resource control mechanisms within SOEs. Owing to dissimilarities in evaluation protocols and the hierarchical configuration of SOEs, the innovation orientation of state ownership revealed a hierarchical pattern: central state ownership tends to foster innovation, while local state ownership tends to impede it. The result was shown to be robust by a series of checks, including alternative dependent variables, subsample tests, the Poisson model, the Tobit model, the Heckman two-step sample selection model, and the application of a two-step Data Envelopment Analysis model to control for managerial ability.

Additionally, this paper substantiated the existence of two influential channels through which state ownership heterogeneity impacts corporate innovation – the input channel and the efficiency channel. The hierarchical structure extends its influence to these pivotal facets of corporate innovation, with central state ownership positively affecting both channels and local state ownership exerting a negative influence.

This study contributes to the literature on state ownership and corporate innovation within the framework of institutional theory. Prior research has underscored the pivotal role of political affiliations in overcoming institutional voids in emerging markets [15; 17]. This study suggests that state ownership serves as a crucial means for accessing scarce resources and addressing institutional voids. Simultaneously, the heterogeneous impact of central and local state ownership on corporate innovation indicates that state-owned enterprises may exhibit varying levels of innovation inputs, innovation efficiency, and innovation outputs due to distinct institutional pressures stemming from state ownership heterogeneity. These findings illuminate the intricate interplay between China's institutional landscape, state ownership, and corporate innovation, providing fresh insights into the ongoing development of institutional perspectives.

Furthermore, our findings have significant practical implications for emerging countries seeking to emulate the Chinese system of governance in their transition to an innovative economy. In such contexts, the government's control over corporate ownership is divided between the central and local governments, whose institutional frameworks may be said to consist of government entities rather than purely private enterprises. Our findings suggest that the personnel control systems of hierarchical state ownership take different approaches to the political promotion and incentives of managers of state-owned enterprises, making central state ownership more conducive to corporate innovation. Additionally, the conclusions of this study imply that policymakers should recognize the nuanced relationship between state ownership and corporate innovation to take institutional differences into account for the purposes of creating appropriate innovation-oriented systems and avoiding a one-size-fits-all approach.

At the same time, this study has several limitations. First, it does not split local state ownership types into sub-levels. For example, the impact of local state ownership may change if one considers the provincial, city, and county levels separately. Second, the generalisability of the findings is limited by our use of a single country as the research context. Future work should address these limitations by considering a more fine-grained decomposition of the various forms of local state ownership, as well as other transitioning economies. These extensions would further develop our understanding of corporate innovation in a transition economy from a hierarchical state ownership perspective.

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