NZFM2019-Innovation and ultimate controlling shareholders in China: Should the state shrink itself to residuals?

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ABSTRACT

This paper examines the effects of ownership structure reform on corporate innovation performance in a transition economy. Specifically, we highlight the importance of identifying the ultimate controlling shareholders in investigating the ownership-innovation nexus. We argue that non-state ownership of listed firms is not necessarily superior to certain types of state ownership because different types of ultimate controlling shareholders possess various objectives, motivations, resources, and capabilities that will influence how they exercise their control rights over the firms they invest in. Drawing on data from 2,739 listed firms in China between 2007 and 2015, we find that R&D intensity is most strongly associated with non-state controlling ownership, whereas the "national champions", state-owned enterprises (SOEs) controlled by the central government, show the strongest performance in innovation outputs. Local-government controlling ownership appears to be the weakest link in terms of both innovation inputs and outputs. These findings contribute to the policy-making debate by lending support to the Chinese government's selective privatization strategy. That is, instead of shrinking itself to residuals, the state should build up the "national champions", which can team up with the vigorous non-state sector to be key enablers in China's plan to encourage indigenous innovation.

JEL classification: O31; O38; G32; G34
Keywords: Innovation; ownership structure reform; China

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1. Introduction

Innovation is widely recognized as a major engine of long-term economic growth and a key element of industrialization and catch-up in developing economies (Romer, 1990). However, as emphasized by Belloc (2012), the traditional economics of innovation inspired by Schumpeter (1934, 1942) are unable to explain why firms with similar external conditions can show substantially different innovation performance. Instead, the literature on corporate governance has provided very useful insights into understanding corporate innovation activity because the processes through which individuals integrate their intra-firm human and physical resources are central to the dynamics of corporate innovation.[1] The recent global financial crisis, which has been considered a corporate governance failure (Mallin, 2010), has stimulated a vigorous discussion regarding how to ensure an efficient link between finance and enterprise to unleash innovation and productivity for sustainable growth from a corporate governance perspective (OECD, 2012). The role played by corporate owners has been a key part of this discussion because the corporate ownership structure determines the control power of a firm's decision makers over resource allocation and their incentives to invest in the innovation process (e.g., Aghion et al., 2013).

The research on the ownership-innovation nexus may also provide new insights into the ongoing debate among economists and policymakers about the economic effects of the privatization of state-owned enterprises (SOEs) in transition economies. Estrin et al. (2009) present an excellent literature review on such effects and find quite diverse conclusions. Specifically, they distinguish and separately analyze the effects of privatization on efficiency, profitability, revenues, and other indicators in transition economies over the past fifteen to twenty years. They conclude that the effect of privatization is mostly positive in Central

[1] The other new strand of research associates firms' innovation activities with their organizational characteristics based on an evolutionary theory (Belloc, 2012).

Europe. In the Commonwealth of Independent States (CIS), privatization to foreign and domestic owners yields insignificant positive effects and insignificant negative effects, respectively. The findings about China are mixed—the effects of non-state ownership on total factor productivity are mostly positive but sometimes insignificant or negative. Moreover, all the prior studies reviewed by Estrin et al. (2009) do not examine the impact of privatization on corporate innovation performance. However, in the *Transition Report 2014*, the European Bank for Reconstruction and Development (EBRD) highlights the crucial role of innovation in stimulating economic growth in transition economies (EBRD, 2014). They find that, even in countries that seem "stuck in transition" (p. 4), individual firms can make a difference through management practices concerning innovation. In other words, managers can make decisions about innovation that have a substantial impact on the efficiency and productivity of their businesses, regardless of a country's level of economic development or its progress along the transition path.

As a major transition economy, China offers a unique platform for investigating the ownership-innovation nexus. On the one hand, China has experienced remarkable growth since economic reform was introduced in the late 1970s; in terms of size, China has the world's second largest economy, after the United States. However, the sustainability of such rapid growth is a major concern due to China's heavy dependence on foreign technology transfer and imitation. In addition, China is being forced toward a more skill-intensive and technology-intensive growth path because its amount of surplus unskilled labor has decreased and because the resource and environmental constraints for sustainable growth have become increasingly significant. To address this critical issue, the Chinese government began changing its development strategy in 2006, making the development of indigenous innovation the top priority in its national development plan (Fu, 2015). On the other hand, unlike its peers in Central and Eastern Europe (CEE) and the CIS, the Chinese government has not

included large-scale privatization in its transition. Instead, it has adopted a gradual approach to economic reform by selectively privatizing its economy, thereby avoiding the transition recession observed in CEE and the CIS (Estrin et al., 2009). This approach has been further emphasized in China's latest five-year plan released in 2011, which indicates that China is pursuing a "national champion" strategy for certain industries that the government considers important (Szamosszegi and Kyle, 2011). Therefore, China's experiences with innovation and ownership structure reform have become a subject of widespread interest among various stakeholders in economics and politics.

To the best of our knowledge, few empirical studies have considered the impact of state ownership when estimating the determinants of firms' innovation performance in China. Keister and Hodson (2009) use data for 800 Chinese firms from 1994 to 1999 to study the relationship between ownership type and organizational innovation. The empirical results suggest that SOEs are more likely than collective enterprises and other non-state firms to adopt innovations. Using data on 142 listed firms in China from 2005 to 2007, Dong and Gou (2009) study the influence of corporate governance factors on firm R&D investment and find that state ownership has no significant impact on R&D investment. Employing a sample of 548 listed Chinese firms from 2001 to 2004, Choi et al. (2011) investigate the impact of ownership structures on firm innovation performance, as measured by the number of patent registrations, and observe a significantly positive but lagged relationship between state ownership and innovation.[2]

This study attempts to extend the previous literature by estimating the impacts of ownership structure reform on corporate innovation performance using a large sample of

[2] Using a sample of 370 mostly private and relatively small Chinese firms in Zhejiang province for the 2004–2006 period, Shapiro et al. (2015) investigate the degree to which corporate governance and ownership influence the innovation performance of firms in China. They find that corporate governance and ownership affect innovation activity more strongly when innovation is measured by patenting activity rather than by new product sales. However, their finding mainly applies to non-state firms because SOEs only account for 5% in their sample and because excluding SOEs does not change the empirical results.

listed firms in China for the 2007–2015 period. Specifically, we divide ultimate controlling shareholders in China into three types—central government, local government, and non-state shareholders—and examine whether their impacts on firm innovation performance differ.[3] In addition, we further investigate how the concentration of voting rights held by different types of ultimate controlling shareholders influences corporate innovation. This study contributes to the literature in the following ways. First, this study contributes to the debate on the role of state in innovation process in transition economies by differentiating the influence of central government from that of local governments.[4] Previous studies on firm innovation and ownership have employed a simple approach to classify China's listed firms into state- and non-state-owned firms to examine whether state ownership has a positive or negative effect on the innovation performance of firms in China (Dong and Gou, 2010; Choi et al., 2011). However, this simple classification might ignore institutional realities because, in China, state shares are ultimately controlled by two different types of investors, i.e., the central government and local governments. This further classification is essential because local governments might have different innovation-related interests and resources than their central government counterpart does. In addition, this separation is particularly interesting to current policymakers in China because China is at a crossroads in ownership structure reform; the findings may offer insights regarding whether central government and local government ownership should be considered separately when formulating the national innovation plan and, if so, how.

Second, this study complements the existing literature by using the ultimate controlling shareholder as an indicator for the real identity of the dominant shareholder and by investigating its impact on corporate innovation activity in China. Previous studies have

[3] Because the number of firms with foreign ultimate controlling ownership is very small (233 of 17,105 in our sample), we do not divide non-state ownership into domestic non-state ownership and foreign ownership.
[4] Please refer to Belloc (2014) for a summary of the debate.

focused on the ownership structure of direct ownership, which may fail to identify the real dominant shareholder because the control rights (who, *de facto*, runs the corporation, i.e., voting rights) are different from the cash flow rights generated from direct ownership.[5] Therefore, our study employs the La Porta et al. (1999) method to identify the ultimate controlling shareholder and to investigate its role in corporate innovation activities in China.

Third, this study complements the previous research on firm innovation and ownership by including both an input-oriented innovation indicator (i.e., R&D expenditures) and an output-oriented innovation measurement (i.e., the number of patents) in the models to investigate the impacts of ultimate controlling shareholders on firms' innovation performance. Firms' R&D expenditures are a key indicator of their innovative efforts, whereas their total number of patents is a major measurement of their innovative capacity. Including both items in our models enables us to compare them and to draw a relatively comprehensive picture of the influences of various ultimate controlling shareholders between the two key stages of innovation.

Finally, this study extends prior research by using data after the split-share structure reform and by applying new accounting principles to test these issues. Before 2006, two-thirds of outstanding shares were non-tradable and were directly and indirectly controlled by central or local governments. Several studies have argued that these government-controlled non-tradable shares frequently expropriate the interests of minority shares of tradable shares (La Porta et al., 2000; Sun and Tong, 2003; Bai et al., 2004; Wei et al., 2005). In addition, Allen et al. (2005) note that China's legal framework and institutions are underdeveloped, as evidenced by poor corporate governance, low accounting standards, and loose investor protection systems. To address these issues, the Chinese government launched a series of reforms aimed at promoting privatization, improving corporate governance and advancing the

[5] The cash flow right is approximately how much and in what order claimholders get paid. The control right concerns who makes decisions with respect to the use of firm assets and under what circumstances.

development of institutional investors. Moreover, in 2007, new accounting standards were adopted in China to approximate international standards, and the local Generally Accepted Accounting Principles (GAAP) shifted to International Financial Reporting Standards (IFRS) to provide more reliable financial information and to reduce information asymmetries. Thus, this study is of interest to potential domestic and foreign investors because its use of this new sample elucidates these changes in China.

The remainder of this paper is organized as follows. Section 2 includes a literature review and hypothesis development. Section 3 describes the data and the econometric methodology. Section 4 presents the empirical results, and section 5 concludes the study.

2. Theoretical background and hypothesis development

2.1. Type II agency problems and ultimate controlling shareholders

The finance literature describes two types of agency problems: Type I agency problems for conflicts between owners and managers (Jensen and Meckling, 1976) and Type II agency problems for conflicts between controlling shareholders and minority shareholders (Dharwadkar et al., 2000). Type I agency problems prevail in developed economies because ownership and control are often separated and legal mechanisms protect owners' interests. However, in developing economies, Type II agency problems represent a more serious issue due to the prevalence of concentrated ownership and the absence of effective external governance mechanisms (Young et al., 2008). In such cases, the controlling shareholder typically has power significantly in excess of its cash flow rights, which causes the agent to latch onto the controlling shareholders and to ignore or even expropriate minority shareholders' interests[6] (La Porta et al., 2000; Yao et al., 2010).

[6] Expropriation can be accomplished by (1) placing less-than-qualified family members, friends, and cronies in

As a developing economy, China encounters this exact type of agency problem. Compared with Western companies, Chinese firms face more severe Type II agency problems because of controlling shareholders' significant stock ownership and control over firms' boards of directors (Jiang et al., 2010; Johnson et al., 2000; Li and Zhang, 2010). In particular, Type II agency problems lie between the ultimate controlling shareholder and the minority shareholders because, in China, the divergence between the controlling owners' cash flow rights and voting rights is mostly maintained through pyramid structures (Claessens and Yurtoglu, 2013).[7] This type of agency problem is exacerbated by investors' poor legal protection and underdeveloped capital markets (Allen et al., 2005). Therefore, it is crucial to adopt the concept of ultimate controlling ownership rather than direct ownership in investigating the ownership-innovation nexus in China.

2.2. Ultimate controlling shareholders and innovation

Ultimate controlling shareholders in China are divided into three categories—central government, local government, and non-state shareholders—because the impact of the central government can be quite different from that of local governments in terms of corporate innovation activities. First, local governments' interests may differ from those of the central government. As explicitly indicated in the official website of CHINA.ORG.CN, "contradictions still exist between the Central Government and local governments".[8] Furthermore, the 23rd Audit Report released by China's National Audit Office on June 28, 2015 stated that "the central policies and measures were not completely put into effect by 18

key positions (Faccio et al., 2001); (2) purchasing supplies and materials at above-market prices or selling products and services at below-market prices to organizations owned by or associated with controlling shareholders (Chang and Hong, 2000; Khanna and Rivkin, 2001); and (3) engaging in strategies, such as excessive diversification, that advance personal, family, or political agendas at the expense of firm performance (Backman, 1999).

[7] Please refer to Appendix A for further detail on ultimate controlling ownership.

[8] CHINA.ORG.CN is the authorized government portal site for China, which is published under the auspices of the State Council Information Office. Please refer to the following link for details: www.china.org.cn/english/features/Q&A/161686.htm.

units", including Fuxin city and Huludao city in Liaoning Province, Siping city in Jilin Province, and the Shanghai Municipal Government (NAO, 2015). Therefore, although innovation has been emphasized as a top priority in China's national development plan, local governments might opt to avoid fully implementing this policy; hence, the listed firms ultimately controlled by these local governments might have fewer incentives and motivations to develop indigenous innovation. Second, China is renowned for its highly centralized political system. According to China's constitution, the division of functions and powers between the central and local governments is guided by the principle of providing local authorities with the full scope of initiative and enthusiasm under the unified leadership of the central authorities. Therefore, the central government is better able to mobilize social and financial resources to promote innovation than its local counterparts. Third, the SOEs directly controlled by the central government are clustered into sectors of "strategic importance", such as mining, energy, transportation, telecommunications, banking, and public utilities, and they are closely monitored by the central government, even though they are dispersed across the country. Their chairs are usually carefully chosen according to their ability, and many eventually became vice ministers in China (Chen et al., 2009). The SOEs controlled by local governments may outnumber—but are dwarfed by—their central counterparts. These local SOEs are involved in almost every industry, including information technology, machinery, automobiles, hotels, and hospitality, and they are usually subject to looser supervision than their central peers.

Specifically, according to the Unirule Institute of Economics (2011), China has two forms of central government ownership: (1) SOEs managed by the State-owned Assets Supervision and Administration Commission of the State Council (SASAC-SC) and (2) SOEs supervised by the Ministry of Finance (MF). As indicated on its official website, the SASAC-SC performs investors' responsibilities, supervises and manages enterprises'

state-owned assets under the supervision of the central government, and enhances the management of state-owned assets. The SASAC-SC is also responsible for preserving and increasing the value of the supervised enterprises' state-owned assets and for managing wages, remunerating the supervised enterprises, formulating policies to regulate the income distribution of the supervised enterprises' top executives and organizing the implementation of these policies. Moreover, the SASAC-SC appoints and removes the supervised enterprises' top executives and evaluates their performance through legal procedures; it either grants rewards or imposes punishments based on this performance. The industrial industry and part of the financial industry are the main industries managed by the SASAC-SC. By contrast, as indicated on its official website, the MF's main functions include supervising state-owned financial institutions and state-owned assets affiliated with other central government ministries, such as the Ministry of Commerce, the Ministry of Education, and the Ministry of Science and Technology. Thus, the MF complements the SASAC-SC by focusing on non-industrial sectors.

China also has two local government owners: the State-owned Assets Supervision and Administration Commission of Local Governments (SASAC-LG) and other units of the local governments (LGs). Although the basic functions of the SASAC-SC and the SASAC-LG are quite similar, they differ in three key ways. First, according to the Law of the People's Republic of China on the State-owned Assets of Enterprises, issued in October 2008 (hereafter referred to as the "Law"), although both the SASAC-SC and the SASAC-LG manage SOEs, the SASAC-SC focuses on large SOEs that impact the national economic lifeline and state security determined by the central government and on SOEs in fields with important infrastructure and natural resources, whereas the SASAC-LG covers other SOEs. Second, the Law also indicates that both the SASAC-SC and the SASAC-LG manage SOEs on behalf of and with the authorization of the corresponding government. The SASAC-LG

participates in major decision making, the selection of managers and other SOE rights on behalf of the corresponding local government. In addition, the SASAC-LG accepts supervision and assessment by the corresponding local government. Therefore, the SASAC-SC follows the central government's policies and instructions, whereas the SASAC-LG must follow the local governments' policies and instructions. Third, according to the Notice of the SASAC-SC on Issuing Some Advice on Further Strengthening the Supervision and Administration of Local State-owned Assets, issued in August 2009 (hereafter referred to as the "Advice"), local governments can include non-industrial industries to expand the scope of the state assets managed by the SASAC-LG. For example, the SASAC of Beijing Municipality has managed more than 95% of the local state-owned assets.

Innovation is the lifeline of firms' sustainable development. Thus, innovation is a critical agenda item for both public and private ultimate controlling shareholders. Privately owned firms must innovate to survive in the competitive market; they must innovate or die. In addition, as indicated in Fu (2012), the importance of internal incentives for innovation may decrease when a firm's capability to obtain external resources for its innovation activity increases. Given that SOEs generally have greater access to external resources for innovation than their private counterparts, non-state-owned firms are assumed to have the strongest incentives for innovation. Compared with their local counterparts, central government-owned firms would have stronger incentives to innovate because innovation has become the top priority in China's official national development plan. In addition, these firms are subject to strict monitoring by the central government, and their top executives are carefully selected and can climb the state hierarchy if they perform well in their jobs. However, local government-owned firms might have to entertain some other economic and social goals established by their local superiors, such as lower unemployment rates and higher GDP

growth rates. Moreover, these firms are usually subject to less supervision. Hence, compared with their central counterparts, they might have less incentive/motivation to maintain innovation as their top priority. Therefore, we argue that, in China, listed firms ultimately controlled by non-state units have the strongest incentives for innovation, followed by those controlled by the central government, whereas the listed firms controlled by local governments have the weakest incentives for innovation.

Turning to resources for innovation, Belloc et al. (2016) indicates that SOEs generally enjoy better external resources for innovation than their private counterparts. On the one hand, by imposing different fiscal and lending policies, SOEs can finance basic and less-applied research to a greater extent than private firms, which can fund research activities regardless of the necessary revenues from research output and/or the uncertainty involved in risky innovative projects. Moreover, the government has a higher capacity to lead knowledge networks via two channels. First, SOEs can engage more easily than private firms in inter-firm collaborations (including patent sharing and cross-licensing) for the purpose of innovation production because control rights are wholly and partly concentrated in the hands of one owner—the state. Second, given their superior access to information about economic performance and trends, SOEs can more easily coordinate intra-industrial change, thereby leading industrial districts and local systems of innovation. Furthermore, in addition to the long-term capital and knowledge networks enjoyed by the SOEs mentioned above, Chinese governments can also provide other key resources, such as land, resident status and related public benefits, which are critical to firm innovation (Tan, 2006; Choi et al., 2011; Firth et al., 2011).[9] Compared with state investors, domestic non-state investors typically possess larger social networks in the home market, in addition to their family, kin, and other interpersonal

[9] For instance, local resident status in China is associated with numerous public benefits and is thus important for attracting highly skilled labor. Third, access to land contributes to firm innovation because limited land availability and high estate prices remain major constraints on innovation activities, which often require large R&D centers.

relationships. These social relationships have been found to be more reliable in weak institutional environments in which formal, contractual relations are difficult to build (Filatotchev et al., 2011). They enable local non-state investors to be informed rapidly about local trends and, in turn, to be more responsive to local environments. Thus, domestic owners are more capable of finding timely and accurate information relevant to technology localization and local innovation opportunities, especially in niche markets (Carney, 2005). In addition, domestic non-state owners' local knowledge is difficult to purchase from the market because China lacks a competitive market with professional consultants who specialize in technology localization and local market intelligence (Khanna et al., 2005). As a public administrator, the state does not view the development of local business intelligence as its primary task. Therefore, given the unified leadership of China's central government, we assume that listed firms ultimately controlled by the central government have the best external resources for innovation, followed by those controlled by local governments, and that listed firms controlled by the non-state units have relatively fewer external resources for innovation. Overall, based on the analyses above, we propose the following two key hypotheses.

Hypothesis 1: *Non-state ultimate controlling ownership is related to the best input-oriented corporate innovation performance. Compared with ultimate controlling ownership by local governments, ultimate controlling ownership by the central government is associated with better input-oriented innovation performance.*

Hypothesis 2: *Ultimate controlling ownership by the central government is related to the best output-oriented corporate innovation performance. Compared with local-government ultimate controlling ownership, non-state ultimate controlling ownership is associated with better output-oriented innovation performance.*

3. Methodology and data

3.1. Methodology

Using a sample of Chinese listed firms from 2007 to 2015, we estimate the impacts of ultimate controlling ownership on corporate innovation performance. Our model has the following general form:

$$Innovation_{i,t} = \alpha_0 + \alpha_1 UCS_{i,t} + \alpha_2 C_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where *innovation* is a proxy for a firm's innovation performance; *UCS* indicates a firm's ultimate controlling shareholders; *C* denotes the control variables; and the subscripts *i* and *t* represent the firm and time, respectively.

3.1.1. Innovation

As mentioned above, we use both input- and output-oriented approaches to measure a firm's innovation performance. A popular input-oriented measurement of innovation is a firm's R&D investment intensity (e.g., Coles et al, 2006; Brossard et al., 2013, among others), which is the amount of R&D spending as a percentage of the total assets (*RDTA*). However, this input-oriented measurement contains an implicit assumption, i.e., that R&D efficiency is similar across firms. In other words, firms that spend more on R&D are assumed to be more innovative (Acs and Audretsch, 1987). In terms of innovation output, the number of patents granted (*PATENT*) has been widely used to capture innovation capacity in the innovation literature (Griliches, 1990; Lerner and Wulf, 2007, among others). A possible drawback of patent data is that patents do not necessarily represent a commercially exploited innovation. However, as indicated by Choi et al. (2011), because patent data are collected via a uniform and rigorous process of examination and registration across firms, time periods, and types of technology, they constitute the most detailed and systematically compiled and managed data about innovation in China. Nevertheless, to obtain a more comprehensive picture of corporate

innovation activities in China, we include both input- and output-oriented indicators of innovation performance in our study. Moreover, following Choi et al. (2011), we apply initial year (*t*) to three year (*t*+3) lags to *PATENT* to capture the lead-lag effect of explanatory variables. A variable for the total number of patents over the four years of interest is also generated to conduct a robust interpretation of the results.

3.1.2. Ultimate controlling shareholder

Following Lin et al. (2011), we define the ultimate controlling shareholder as the ultimate owner with the most control rights, and we calculate the ultimate controlling ownership for each listed firm using the approach developed by La Porta et al. (1999).[10] In other words, we classify a firm's ownership type based on the real identity of the owner with the largest ownership control in the firm. Thus, we divide the ultimate controlling ownership into three types: central government, local government, and non-state ownership. First, we use the percentage ownership to distinguish the effects of these three types of ultimate controlling ownerships. The central government's voting rights (*PCENTRAL*) are measured by its percentage ownership if it is the largest owner. The local government's voting rights (*PLOCAL*) are measured by its percentage ownership if it is the largest owner. A non-state investor's voting rights (*PNONSTATE*) are measured by its percentage ownership if it is the largest owner. To test the robustness of the results, we then use dummy variables to differentiate such effects. A company controlled by the central government dummy (*DCENTRAL*) takes a value of one if the firm's ultimate controlling owner is the central government and zero otherwise. A company controlled by the local government dummy (*DLOCAL*) takes a value of one if the firm's ultimate controlling owner is a local government

[10] Ultimate controlling shareholders are also labeled as the largest ultimate owners. According to the Notice of the China Securities Regulatory Commission on Promulgating the Standards Concerning the Contents and Formats of Information Disclosure by Companies Offering Securities to the Public No. 1 — Prospects (Revised 2006), all listed firms in China should provide information concerning their ultimate controlling shareholders.

and zero otherwise. A company controlled by the non-state investor dummy (*DNONSTATE*) takes a value of one if the firm's ultimate controlling owner is a non-state investor and zero otherwise.

3.1.3. Control variables

Following previous studies (Choi et al., 2011; Chen et al., 2014, among others), four control variables are included in the model. Profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of the book value of total assets. Time trend (*TREND*) is included to assess whether there is a significant trend in the movement of the dependent variable over the sample period.[11] To conduct a robust interpretation of the results, we also follow the R&D literatures (e.g., Custódio and Metzger, 2014) and include *RDTA* in the output-oriented innovation equation to measure a firm's R&D effort.

3.2. Data

The sample data initially focus on all companies (A shares) listed on the Shanghai Stock Exchange (SHSE) and on the Shenzhen Stock Exchange (SZSE) for the 2007–2015 period. We then exclude the following listed firms from the sample: (1) Special Treatment (ST) and Particular Transfer (PT) companies; (2) financial companies (e.g., banks, insurance companies, and securities companies) because they are heavily regulated and their return-generating processes differ from those of other companies; and (3) companies with missing values. The ultimate controlling shareholder, R&D expenditures and financial statement data are collected from the CSMAR database and are supplemented with various

[11] The time trend variable could also capture trends in omitted variables.

annual financial reports from individual companies. Patent registration data are hand-collected from the State Intellectual Property Office of the People's Republic of China (SIPO) (http://www.sipo.gov.cn).

The final sample consists of 2,739 listed firms with 17,105 firm-year observations, representing 95% of the listed firms in China. Table 1 provides summary statistics for our sample and shows that the average number of patents owned by a listed firm (*PATENT*) in China is approximately 33, which is much higher than the average (6) reported for Chinese listed firms in 2001 by Choi et al. (2011). This finding is also consistent with the average number of patents presented by Boeing et al. (2016) for Chinese listed firms - approximately 6 for the period 2001-2006 and 32 for the period 2007-2011. There is R&D activity reported for 66.21% of all sample firms, which is higher than the ratio of 47.6% presented by Boeing et al. (2016) for the Chinese listed firms over the period 2001-2011. The results suggest that Chinese firms have dramatically improved their motivation and capability for R&D activities and patent applications over the past decade.[12] The average ratio of R&D expenditures to total assets (*RDTA*) is 1.266%, which is much lower than the average *RDTA* (3.4%) for S&P 1500 firms for the period 1993-2007 reported by Custódio and Metzger (2014). Similarly, the average ratio of R&D expenditures to operating income (*RDOI*) is 2.486%, which is less than the average R&D intensity ratio (3.5%) for firms in six Western European countries in 1996 presented by Munari et al. (2010). These results echo the findings of Fu (2015), i.e., the R&D intensity (measured as the ratio of R&D spending to GDP) in China remains low compared to that in OECD countries, although it has experienced a remarkable increase. Among the sample firms, approximately 15% are ultimately controlled by the central government, 30% are controlled by local governments, and the remaining 55% are controlled by non-state firms.

[12] For example, according to the State Intellectual Property Office of China, ZTE Corporation, a global leader in telecommunications and information technology, had obtained 8,911 patents by 2011.

The average percentage ownerships of these ultimate controlling shareholders across the entire sample are 6%, 12%, and 22%, respectively.[13]

Table 2 presents the mean innovation performance for listed firms with different types of ultimate controlling shareholders and the mean percentage of ultimate ownership within each category. Panel A shows that innovation performance does differ for firms with various types of ultimate controlling shareholders. For example, the average number of patents (*PATENT*) for listed firms ultimately controlled by the central government is approximately 66 per year, whereas the average number of patents for listed firms ultimately controlled by local governments is only 25 per year. The average number of patents for non-state firms is 28 per year, which is slightly higher than that for local government-controlled firms but much lower than that for central government-controlled firms. Focusing on the input-oriented innovation indicator, approximately 77% of non-state controlled firms and 64% of central-government controlled firms report positive R&D expenditures (*RDD*), whereas only 48% of local-government controlled firms have positive investment in R&D. In addition, the average ratio of R&D expenditure to total assets (*RDTA*) for firms ultimately controlled by non-state units is 1.65%, which is higher than that for both central government-controlled firms (1.16%) and local government-controlled firms (0.62%). A similar pattern is observed when the average ratio of R&D spending to operating income (*RDOI*) is employed as the input-oriented measurement of innovation. Turning to the mean percentage of ultimate ownership within each category, the average percentage of ultimate central-government ownership is 43% for central-government controlled firms, which is slightly higher than the average percentage of ultimate local-government ownership (41%) for local-government controlled firms and the average percentage of ultimate non-state ownership (39%) for non-state firms.

[13] The correlation matrix is presented in Appendix B.

Table 1. Descriptive statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
PATENT	32.7769	232.1553	0	8918
LNPATENT	1.6300	1.6704	0	9.0959
RDD	0.6621	0.4730	0	1
RDOI (%)	2.4864	4.5331	0	169.4294
RDTA (%)	1.2657	1.8215	0	40.9575
DCENTRAL	0.1460	0.3532	0	1
DLOCAL	0.3015	0.4589	0	1
DNONSTATE	0.5525	0.4973	0	1
PCENTRAL (%)	6.2422	16.1762	0	86.7100
PLOCAL (%)	12.2003	20.4590	0	89.8900
PNONSTATE (%)	21.5252	22.6791	0	89.9900
LERVERAGE	0.4389	0.2168	0.0071	1.8973
ROA	0.0415	0.0678	-1.9877	2.1635
SIZE	20.7811	1.7022	11.5485	28.5236
TREND	5.6170	2.4919	1	9
No. of observations		17105		

Notes: Firm patents (*PATENT*) are measured by the number of patents owned by a company. *LNPATENT* is the logarithm of one plus the number of patents owned by a company. R&D decision (*RDD*) is a dummy variable that takes a value of one if a company has positive R&D expenditures and zero otherwise. *RDOI* is measured by the ratio of R&D expenditures to operating income. *RDTA* is measured by the ratio of R&D expenditures to total assets. *DCENTRAL* is a dummy variable that takes a value of one if a company is ultimately controlled by the central government and zero otherwise. *DLOCAL* is a dummy variable that takes a value of one if a company is ultimately controlled by a local government and zero otherwise. *DNONSTATE* is a dummy variable that takes a value of one if a company is ultimately controlled by a private entity and zero otherwise. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. Firm profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of operating income. Trend (*TREND*) denotes time trend.

Table 2. Innovation and ultimate controlling shareholders: mean-difference *T* tests

Panel A: Mean

	CENTRAL	LOCAL	NONSTATE
PATENT	66.3787	25.3244	27.96148
RDD	0.6429	0.4825	0.7653
RDOI (%)	2.0227	0.9508	3.4470
RDTA (%)	1.1625	0.6164	1.6472
PCENTRAL/PLOCAL/PNONSTATE (%)	42.7436	40.4665	38.9618
No. of Observations	2498	5157	9450

Panel B: Mean-difference *T* test[a]

	CENTRAL vs NONSTATE	LOCAL vs NONSTATE	CENTRAL vs LOCAL
PATENT	6.7550***	-0.7282	7.0678***
RDD	-12.4760***	-36.1366***	13.3482***
RDOI (%)	-12.7663***	-33.9329***	12.0106***
RDTA (%)	-11.1647***	-33.9166***	15.0994***
PCENTRAL/PLOCAL/PNONSTATE (%)	10.6871***	5.5071***	6.0265***

Notes: Firm patents (*PATENT*) are measured by the number of patents owned by a company. R&D decision (*RDD*) is a dummy variable that takes a value of one if a company has positive R&D expenditures and zero otherwise. *RDOI* is measured by the ratio of R&D expenditures to operating income. *RDTA* is measured by the ratio of R&D expenditures to total assets. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. *CENTRAL*, *LOCAL*, and *NONSTATE* refer to companies that are ultimately controlled by the central and local governments and private entities, respectively. Panel B presents t-values from the *T*-test of differences in means. ***, ** and * indicate statistically different from 0 in the *T*-test for means at the 1%, 5%, and 10% levels, respectively.

Panel B of Table 2 tests the significance of inter-group differences and demonstrates that all the main differences reported above are statistically significant. Overall, the simple comparisons of the means of the innovation performance indicators indicate that firms ultimately controlled by the central government perform better in terms of output, those controlled by non-state units perform better in terms of input, and those controlled by local governments perform the worst in terms of both. In addition, the within-group mean percentage of ultimate ownership ranges from 39% to 43% - the differences are small albeit significant.

4. Empirical results

4.1. Main results

Since the dependent variable is left-censored at 0, the Tobit model is employed to estimate Equation (1) (Tobin, 1958), and the results are reported in Table 3. This table contains 12 specifications: (1)–(2) for models in which *RDTA* is the input-oriented measurement of innovation performance and (3)–(12) for models with *LNPATENT* as the output-oriented indicator of innovation performance. Focusing on Panel A, specification (1) shows that the estimated coefficient for *PNONSTATE* is significantly positive; and the estimate coefficient for *PCENTRAL* is positive, albeit insignificant, whereas the estimated coefficient for *PLOCAL* is significantly negative. This result suggests that as the percentage of ultimate local-government controlling ownership increases, the R&D expenditure ratio decreases. By contrast, greater ultimate non-state controlling ownership leads to a higher R&D expenditure ratio. Higher and lower ultimate central-government controlling ownership might have no significant influence on firms' R&D expenditure ratio. The estimated magnitude of *PNONSTATE* illustrates that a 1% increase in firm ownership by non-state

investors leads to an increase in firms' R&D expenditure ratio by 0.0037%. By contrast, the estimated magnitude of *PLOCAL* shows that a 1% increase in firm ownership by local governments results in a decrease in firms' R&D expenditure ratio by 0.0053%. This finding lends support to Hypothesis 1, i.e., non-state firms perform best in terms of R&D inputs, followed by central government-controlled firms and local government-controlled firms. The estimated coefficients for *DCENTRAL* and *DLOCAL* presented in Specification (2) are significantly negative, and the estimated magnitudes for these two variables are -0.1318 and -0.3515, respectively. This result indicates that non-state ultimate controlling ownership would lead to higher R&D expenditures, whereas both central and local government ownership would lead to lower R&D inputs, with the latter's inputs decreasing to a greater extent. This finding provides additional evidence supporting Hypothesis 1. This finding is partially in agreement with Dong and Gou (2010), who report that state ownership has no significant impact on firm R&D investment in China.

Turning to Specification (3), the estimated coefficients for *PCENTRAL* and *PNONSTATE* are significantly positive, whereas the estimated coefficient for *PLOCAL* is positive but insignificant. This result suggests that, as the ownership ultimately controlled by the central government or non-state units increases, the number of patents obtained by the firm increases. Meanwhile, higher and lower ultimate local-government controlling ownership might have no significant influence on the number of patents obtained by a firm. The estimated magnitudes of *PCENTRAL* and *PNONSTATE* show that a 1% increase in firm ownership ultimately controlled by the central government and non-state units results in an increase in the number of patents granted by 0.0095% and 0.0063%, respectively. This finding supports Hypothesis 2, i.e., central government-controlled firms produce the greatest innovation outputs in terms of the number of patents, followed by non-state-controlled firms and local government-controlled firms. In addition, the estimated coefficients for *DCENTRAL*

and *DLOCAL* reported in Specification (4) are significantly positive and negative, respectively. This result confirms Hypothesis 2, which suggests that central-government controlled firms generate more patents, while local government-controlled firms generate fewer patents. This finding is consistent with both Keister and Hodson (2009) and Choi et al. (2011), who also report a positive relationship between state ownership and innovation outputs. The estimated coefficients reported in Specifications (5)–(12) are quite similar to those reported in Specifications (3)–(4), suggesting that the above finding is robust after controlling for the lead-lag effect of explanatory variables. In general, our results concerning the differences between the central government- and local government-controlled firms are partially consistent with Chen et al. (2009), who report that central government-controlled firms perform better than their local counterparts in terms of ROA. The estimated coefficients for the control variables suggest that greater profitability, lower leverage, and larger firm size tend to be associated with significantly better innovation performance, which is largely consistent with the literature.

Panel B demonstrates the statistical significances of the differences between the various categories of ultimate controlling ownership. In general, the Chi^2 statistics shown in Panel B indicate that the differences in the coefficients for both input- and output-oriented innovation performance indicators across all different types of ultimate controlling ownership are statistically significant. The results provide further support to both Hypotheses 1 and 2.

4.2. Robustness checks

First, because the ratio of R&D expenditures to operating income (*RDOI*) and the R&D decision dummy (*RDD*) have also been the popular measurements of innovation performance in previous studies (e.g., Cohen and Kelpper, 1996; Lin et al., 2011, among others), we employ these two measures as the alternative indicators of input-oriented innovation

performance, and we re-run Equation (1), respectively. The results are reported in Tables 4 (*RDOI*) and 5 (*RDD*). The estimated ownership coefficients provided in Panel A of both tables are nearly the same as those reported in Panel A of Table 3. Again, almost all of the differences in the ownership coefficients presented in Panel B of Tables 4 and 5 are statistically significant. The results suggest that our finding is robust to the alternative input-oriented innovation indicators and lends further support to both Hypotheses 1 and 2.

Second, following Choi et al. (2011), we also use a listed firm's number of patents (*PATENT*) as an alternative measurement of output-oriented innovation performance. Given the presence of dynamic count data, we employ negative binomial regression analysis to re-run Equation (1), and the results are presented in Table 6. Again, the estimated coefficients for the key variables are quite similar to those reported in Specifications (3)–(12) in Table 3, which suggests that our finding is robust to an alternative output-oriented innovation indicator and provides further support for Hypothesis 2.

Finally, another concern about our results is that significant industry effects might exist because of regulation and monopoly. To address this issue, we follow Chen et al. (2009) and divide the full sample into two sub-samples representing manufacturing and non-manufacturing industries. Regulations and monopoly are assumed to be largely absent in the manufacturing industry. The regression results reported in Panel A of both Tables 7 (for the manufacturing industry) and 8 (for the non-manufacturing industry) are broadly the same across the two sub-samples. The only exceptions are observed in Panel B of both Tables. The Chi^2 statistics listed in Specifications (1)-(2) in Panel B of Table 7 indicate that the difference between the coefficients of *PCENTRAL* and *PNONSTATE* is statistically insignificant. In addition, the Chi^2 statistics reported in Specifications (3)-(12) in Panel B of Table 7 also show that the differences between the coefficients of *PLOCAL* and *PNONSTATE* are statistically insignificant in most cases. Similar patterns are observed when the ownership dummy

variables (i.e., *DCENTRAL*, *DLOCAL*, and *DNONSTATE*) are used in the regressions to replace the above-mentioned ownership percentage variables. These results suggest that in the manufacturing industry, non-state controlled firms are not necessarily superior to central-government controlled SOEs in terms of R&D investment intensity. Meanwhile, local-government controlled SOEs are not necessarily inferior to non-state controlled firms in terms of patent generation. Regardless, local-government controlled SOEs remain associated with the lowest R&D investment intensity, and central-government controlled SOEs remain related to the greatest patent generation in the manufacturing industry.

The Chi^2 statistics listed in Specifications (1)-(2) in Panel B of Table 8 indicate that the difference between the coefficients of *PCENTRAL* and *PLOCAL* is statistically insignificant. A similar pattern is demonstrated when the ownership dummy variables are used in the regressions to replace the ownership percentage variables. This result indicates that, unlike what occurs in the manufacturing industry, the ultimate central-government controlling shareholders exert similar efforts in stimulating R&D expenditure ratios as their local counterparts. In any case, non-state firms remain associated with the highest R&D investment intensity, and central-government controlled SOEs remain related to the greatest patent generation. In general, the results confirm Hypotheses 1 and 2 to a great extent.

These findings are not surprising because regulations and monopoly are assumed to be largely absent in the manufacturing industry (Belloc, 2014). Thus, SOEs should contend with the non-state controlled firms in a more competitive environment. Hence, the central-government controlled SOEs in the manufacturing industry assume more efforts in R&D investment compared to their peers in the non-manufacturing industry to compete with the non-state firms. Conversely, the non-manufacturing industry is usually subject to more regulations than the manufacturing industry. Hence, the central government is better able to exert monopoly power on the non-manufacturing industry in achieving their goals;

consequently, these “national champions” make similar efforts in terms of R&D expenditure intensity to their local counterparts.

Table 3. Innovation (*RDTA-LNPATENT*) and ultimate controlling shareholders

	$RDTA_t$		$LNPATENT_t$		$LNPATENT_{t+1}$		$LNPATENT_{t+2}$		$LNPATENT_{t+3}$		$LNPATENT_{t\sim t+3}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Main results												
PCENTRAL	0.0001		0.0095***		0.0117***		0.0143***		0.0149***		0.0097***	
	(0.0016)		(0.0014)		(0.0016)		(0.0018)		(0.0019)		(0.0019)	
PLOCAL	-0.0053***		0.0017		0.0022		0.0033**		0.0036**		-0.0006	
	(0.0014)		(0.0012)		(0.0014)		(0.0015)		(0.0016)		(0.0016)	
PNONSTATE	0.0037***		0.0063***		0.0055***		0.0069***		0.0048***		0.0056***	
	(0.0012)		(0.0010)		(0.0012)		(0.0013)		(0.0015)		(0.0014)	
DCENTRAL		-0.1318**		0.1850***		0.3134***		0.3500***		0.4032***		0.1296*
		(0.0620)		(0.0553)		(0.0623)		(0.0679)		(0.0742)		(0.0776)
DLOCAL		-0.3515***		-0.1135***		-0.0886*		-0.1311**		-0.0472		-0.3014***
		(0.0493)		(0.0438)		(0.0496)		(0.0538)		(0.0584)		(0.0603)
RDTA			0.1019***	0.1025***	0.0881***	0.0883***	0.0717***	0.0718***	0.0427***	0.0427***	0.0497***	0.0500***
			(0.0061)	(0.0061)	(0.0068)	(0.0068)	(0.0076)	(0.0076)	(0.0087)	(0.0087)	(0.0066)	(0.0065)
ROA	0.9008***	0.9116***	-0.1479	-0.0900	0.3215**	0.3669**	0.7258***	0.7762***	0.7221***	0.7793***	0.6320***	0.6533***
	(0.1593)	(0.1589)	(0.1238)	(0.1235)	(0.1521)	(0.1518)	(0.1704)	(0.1701)	(0.2096)	(0.2094)	(0.1964)	(0.1960)
LEVERAGE	-0.7352***	-0.7467***	0.1304**	0.0985	0.0613	0.0351	0.0589	0.0366	-0.0792	-0.0829	0.0301	0.0518
	(0.0805)	(0.0804)	(0.0654)	(0.0654)	(0.0770)	(0.0771)	(0.0874)	(0.0876)	(0.0995)	(0.0998)	(0.0882)	(0.0882)
SIZE	0.0372***	0.0367***	0.0321***	0.0329***	-0.0069	-0.0058	-0.0129*	-0.0106	-0.024***	-0.0207***	0.0079	0.0103*
	(0.0080)	(0.0080)	(0.0064)	(0.0064)	(0.0068)	(0.0068)	(0.0071)	(0.0070)	(0.0077)	(0.0077)	(0.0057)	(0.0057)
TREND	0.1471***	0.1463***	0.0946***	0.0935***	0.0861***	0.0855***	0.0630***	0.0625***	0.0329***	0.0336***	0.1714***	0.1702***
	(0.0037)	(0.0038)	(0.0030)	(0.0030)	(0.0037)	(0.0037)	(0.0046)	(0.0047)	(0.0060)	(0.0060)	(0.0045)	(0.0045)
Constant	-0.5146**	-0.3484	-0.4520**	-0.2245	0.4034*	0.6028***	0.5534**	0.7809***	1.1313***	1.2583***	0.4913*	0.7152***
	(0.2182)	(0.2141)	(0.1853)	(0.1823)	(0.2100)	(0.2064)	(0.2352)	(0.2321)	(0.2622)	(0.2588)	(0.2564)	(0.2533)
Industry dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Wald chi^2	2802.32***	2788.97***	2519.03***	2452.98***	1560.35***	1526.31***	1027.94***	989.58***	745.52***	711.70***	2423.65***	2420.73***
Obs.	17105	17105	17105	17105	14077	14077	11599	11599	9312	9312	8961	8961

Panel B: Test of equality in coefficients (Chi^2 statistics)

PCENTRAL vs PNONSTATE	6.26**		6.11**		18.32***		22.51***		35.47***		5.26**	
PLOCAL vs PNONSTATE	59.48***		19.60***		7.80***		7.92**		0.78		18.97***	
PCENTRAL vs PLOCAL	13.54***		35.79***		42.63***		50.02***		45.34***		38.77***	
DCENTRAL vs DNONSTATE		4.53**		11.18***		25.28***		26.54***		29.55***		2.79*
DLOCAL vs DNONSTATE		50.80***		6.71***		3.20*		5.95*		0.65		25.02***
DCENTRAL vs DLOCAL		12.22***		29.57***		43.38***		53.40***		39.69***		39.55***

Notes: This table shows the relationship between ultimate controlling ownership and innovation performance estimated using Tobit regression. Innovation performance is measured by *RDTA*, the ratio of R&D expenditures to total assets. The first dependent variable (specifications 1-2) is *RDTA*. The second dependent variable (specifications 3-4) is $LNPATENT_t$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t*. The third dependent variable (specifications 5-6) is $LNPATENT_{t+1}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+1*. The fourth dependent variable (specifications 7-8) is $LNPATENT_{t+2}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+2*. The fifth dependent variable (specifications 9-10) is $LNPATENT_{t+3}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+3*. The last dependent variable (specifications 11-12) is $LNPATENT_{t\sim t+3}$, which is measured by the logarithm of one plus the total number of patents owned by a company for 4 years from *t* to *t+3*. *DCENTRAL* is a dummy variable that takes a value of one if a company is ultimately controlled by the central government and zero otherwise. *DLOCAL* is a dummy variable that takes a value of one if a company is ultimately controlled by a local government and zero otherwise. *DNONSTATE* is a dummy variable that takes a value of one if a company is ultimately controlled by a private entity and zero otherwise. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. Firm profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of operating income. Trend (*TREND*) denotes time trend. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses.

Table 4. Innovation (*RDOI-LNPATENT*) and ultimate controlling shareholders (Robustness check 1)

	$RDOI_t$		$LNPATENT_t$		$LNPATENT_{t+1}$		$LNPATENT_{t+2}$		$LNPATENT_{t+3}$		$LNPATENT_{t\sim t+3}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Main results												
PCENTRAL	-0.0083**		0.0096***		0.0117***		0.0143***		0.0150***		0.0098***	
	(0.0042)		(0.0014)		(0.0016)		(0.0018)		(0.0019)		(0.0019)	
PLOCAL	-0.0163***		0.0015		0.0019		0.0031**		0.0036**		-0.0005	
	(0.0036)		(0.0012)		(0.0014)		(0.0015)		(0.0016)		(0.0016)	
PNONSTATE	0.0042		0.0066***		0.0056***		0.0069***		0.0049***		0.0057***	
	(0.0030)		(0.0010)		(0.0012)		(0.0013)		(0.0015)		(0.0014)	
DCENTRAL		-0.4252***		0.1785***		0.3057***		0.3484***		0.4029***		0.1307*
		(0.1606)		(0.0560)		(0.0630)		(0.0685)		(0.0745)		(0.0779)
DLOCAL		-0.8602***		-0.1276***		-0.1004**		-0.1385**		-0.0504		-0.2997***
		(0.1277)		(0.0443)		(0.0501)		(0.0542)		(0.0586)		(0.0605)
RDOI			0.0228***	0.0227***	0.0188***	0.0187***	0.0192***	0.0192***	0.0122***	0.0122***	0.0168***	0.0168***
			(0.0024)	(0.0024)	(0.0027)	(0.0027)	(0.0034)	(0.0034)	(0.0038)	(0.0038)	(0.0029)	(0.0029)
ROA	-2.2346***	-2.2665***	-0.0177	0.0416	0.4360***	0.4809***	0.8023***	0.8522***	0.7696***	0.8266***	0.7230***	0.7450***
	(0.4055)	(0.4043)	(0.1243)	(0.1240)	(0.1526)	(0.1523)	(0.1708)	(0.1706)	(0.2101)	(0.2099)	(0.1968)	(0.1965)
LEVERAGE	-2.6571***	-2.6555***	0.1218*	0.0885	0.0437	0.0169	0.0548	0.0324	-0.0794	-0.0832	0.0324	0.0534
	(0.2075)	(0.2070)	(0.0659)	(0.0659)	(0.0775)	(0.0776)	(0.0881)	(0.0883)	(0.1001)	(0.1004)	(0.0884)	(0.0884)
SIZE	-0.0801***	-0.0840***	0.0362***	0.0370***	-0.0042	-0.0031	-0.0108	-0.0086	-0.023***	-0.0196**	0.0092	0.0103*
	(0.0205)	(0.0204)	(0.0064)	(0.0064)	(0.0068)	(0.0068)	(0.0071)	(0.0071)	(0.0077)	(0.0077)	(0.0057)	(0.0057)
TREND	0.2923***	0.2908***	0.1029***	0.1019***	0.0957***	0.0951***	0.0708***	0.0704***	0.0377***	0.0384***	0.1764***	0.1754***
	(0.0095)	(0.0096)	(0.0030)	(0.0030)	(0.0037)	(0.0037)	(0.0045)	(0.0045)	(0.0059)	(0.0059)	(0.0044)	(0.0044)
Constant	3.2120***	3.4869***	-0.5352***	-0.2962	0.3373	0.5428***	0.4821**	0.7122***	1.0846***	1.2133***	0.4377*	0.6621***
	(0.5613)	(0.5509)	(0.1872)	(0.1843)	(0.2119)	(0.2083)	(0.2367)	(0.2336)	(0.2628)	(0.2594)	(0.2570)	(0.2539)
Industry dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Wald chi^2	1981.83***	1980.17***	2304.91***	2236.87***	1425.67***	1391.14***	960.37***	922.57***	726.36***	692.76***	2398.48***	2394.34***
Obs.	17105	17105	17105	17105	14077	14077	11599	11599	9312	9312	8961	8961

Panel B: Test of equality in coefficients (Chi^2 statistics)

PCENTRAL vs PNONSTATE	11.34**	5.27**	17.19***	21.97***	35.22***	5.31**	
PLOCAL vs PNONSTATE	45.73***	23.39***	9.52***	8.9***	0.9	18.92***	
PCENTRAL vs PLOCAL	4.34**	37.72***	44.11***	51.32***	45.90***	38.96***	
DCENTRAL vs DNONSTATE	7.01***	10.16***	23.52***	25.88***	29.25***	2.82*	
DLOCAL vs DNONSTATE	45.37***	8.28***	4.01**	6.53**	0.74	24.57***	
DCENTRAL vs DLOCAL	7.17***	30.45***	43.44***	54.00***	39.97***	39.27***	

Notes: This table shows the relationship between ultimate controlling ownership and innovation performance estimated using Tobit regression. Innovation performance is measured by *RDOI*, the ratio of R&D expenditures to operating income. The first dependent variable (specifications 1-2) is *RDOI*. The second dependent variable (specifications 3-4) is $LNPATENT_t$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t*. The third dependent variable (specifications 5-6) is $LNPATENT_{t+1}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+1*. The fourth dependent variable (specifications 7-8) is $LNPATENT_{t+2}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+2*. The fifth dependent variable (specifications 9-10) is $LNPATENT_{t+3}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+3*. The last dependent variable (specifications 11-12) is $LNPATENT_{t\sim t+3}$, which is measured by the logarithm of one plus the total number of patents owned by a company for 4 years from *t* to *t+3*. *DCENTRAL* is a dummy variable that takes a value of one if a company is ultimately controlled by the central government and zero otherwise. *DLOCAL* is a dummy variable that takes a value of one if a company is ultimately controlled by a local government and zero otherwise. *DNONSTATE* is a dummy variable that takes a value of one if a company is ultimately controlled by a private entity and zero otherwise. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. Firm profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of operating income. Trend (*TREND*) denotes time trend. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses.

Table 5. Innovation (*RDD-LNPATENT*) and ultimate controlling shareholders (Robustness check 2)

	RDD_t		$LNPATENT_t$		$LNPATENT_{t+1}$		$LNPATENT_{t+2}$		$LNPATENT_{t+3}$		$LNPATENT_{t\sim t+3}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Main results												
PCENTRAL	0.0021***		0.0087***		0.0110***		0.0139***		0.0147***		0.0097***	
	(0.0004)		(0.0014)		(0.0016)		(0.0018)		(0.0019)		(0.0019)	
PLOCAL	0.0002		0.0012		0.0018		0.0031**		0.0036**		-0.0004	
	(0.0003)		(0.0012)		(0.0014)		(0.0015)		(0.0016)		(0.0016)	
PNONSTATE	0.0023***		0.0058***		0.0049***		0.0065***		0.0047***		0.0055***	
	(0.0003)		(0.0010)		(0.0012)		(0.0013)		(0.0015)		(0.0014)	
DCENTRAL		-0.0033		0.1731***		0.3042***		0.3414***		0.4007***		0.1376*
		(0.0138)		(0.0553)		(0.0622)		(0.0678)		(0.0740)		(0.0774)
DLOCAL		-0.0796***		-0.1138***		-0.0819*		-0.1255**		-0.0385		-0.2844***
		(0.0110)		(0.0438)		(0.0495)		(0.0537)		(0.0583)		(0.0601)
RDD			0.4131***	0.4201***	0.3901***	0.3942***	0.3233***	0.3254***	0.1993***	0.2003***	0.2260***	0.2246***
			(0.0243)	(0.0243)	(0.0266)	(0.0266)	(0.0287)	(0.0287)	(0.0317)	(0.0317)	(0.0245)	(0.0245)
ROA	0.0730*	0.0941**	-0.0879	-0.0359	0.3840**	0.4249***	0.7495***	0.7977***	0.7421***	0.7983***	0.6547***	0.6772***
	(0.0400)	(0.0399)	(0.1236)	(0.1233)	(0.1518)	(0.1515)	(0.1701)	(0.1698)	(0.2094)	(0.2092)	(0.1961)	(0.1958)
LEVERAGE	-0.1490***	-0.1603***	0.1121*	0.0828	0.0499	0.0259	0.0540	0.0330	-0.0745	-0.0783	0.0245	0.0438
	(0.0193)	(0.0193)	(0.0653)	(0.0654)	(0.0768)	(0.0769)	(0.0872)	(0.0874)	(0.0994)	(0.0996)	(0.0880)	(0.0880)
SIZE	-0.0012	-0.0002	0.0379***	0.0387***	-0.0021	-0.0010	-0.0095	-0.0072	-0.023***	-0.0198***	0.0093	0.0104*
	(0.0020)	(0.0020)	(0.0064)	(0.0064)	(0.0068)	(0.0068)	(0.0070)	(0.0070)	(0.0077)	(0.0077)	(0.0057)	(0.0057)
TREND	0.0632***	0.0628***	0.0835***	0.0822***	0.0735***	0.0727***	0.0507***	0.0501***	0.0237***	0.0243***	0.1616***	0.1606***
	(0.0009)	(0.0009)	(0.0033)	(0.0033)	(0.0040)	(0.0040)	(0.0050)	(0.0050)	(0.0064)	(0.0064)	(0.0048)	(0.0048)
Constant	0.2542***	0.3329***	-0.6277***	-0.4244**	0.2644	0.4391**	0.4607**	0.6756***	1.1026***	1.2231***	0.4411*	0.6581***
	(0.0511)	(0.0504)	(0.1856)	(0.1827)	(0.2099)	(0.2063)	(0.2349)	(0.2317)	(0.2617)	(0.2584)	(0.2556)	(0.2525)
Industry dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Wald chi^2	6715.64***	6587.40***	2537.56***	2479.95***	1617.65***	1588.14***	1073.88***	1036.95***	765.56***	732.11***	2458.27***	2452.22***
Obs.	17105	17105	17105	17105	14077	14077	11599	11599	9312	9312	8961	8961

Panel B: Test of equality in coefficients (Chi^2 statistics)

PCENTRAL vs PNONSTATE	0.55	5.29**	17.65***	21.95***	35.27***	5.56**	
PLOCAL vs PNONSTATE	63.54***	19.42***	7.06***	7.43**	0.59	17.63***	
PCENTRAL vs PLOCAL	31.26***	33.56***	40.19***	48.12***	43.78***	37.93***	
DCENTRAL vs DNONSTATE	0.06	9.80***	23.93***	25.36***	29.29***	3.16*	
DLOCAL vs DNONSTATE	52.01***	6.75***	2.74*	5.47**	0.44	22.36***	
DCENTRAL vs DLOCAL	28.96***	27.32***	40.14***	50.43***	37.81***	38.03***	

Notes: This table shows the relationship between ultimate controlling ownership and innovation performance estimated using Tobit regression. Innovation performance is measured by *RDD*. It is a dummy variable that takes a value of one if a company has positive R&D expenditures and zero otherwise. The first dependent variable (specifications 1-2) is *RDD*. The second dependent variable (specifications 3-4) is $LNPATENT_t$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t*. The third dependent variable (specifications 5-6) is $LNPATENT_{t+1}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+1*. The fourth dependent variable (specifications 7-8) is $LNPATENT_{t+2}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+2*. The fifth dependent variable (specifications 9-10) is $LNPATENT_{t+3}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+3*. The last dependent variable (specifications 11-12) is $LNPATENT_{t\sim t+3}$, which is measured by the logarithm of one plus the total number of patents owned by a company for 4 years from *t* to *t+3*. *DCENTRAL* is a dummy variable that takes a value of one if a company is ultimately controlled by the central government and zero otherwise. *DLOCAL* is a dummy variable that takes a value of one if a company is ultimately controlled by a local government and zero otherwise. *DNONSTATE* is a dummy variable that takes a value of one if a company is ultimately controlled by a private entity and zero otherwise. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. Firm profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of operating income. Trend (*TREND*) denotes time trend. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses.

Table 6. Innovation (*RDTA-PATENT*) and ultimate controlling shareholders (Robustness check 3)

	$PATENT_t$		$PATENT_{t+1}$		$PATENT_{t+2}$		$PATENT_{t+3}$		$PATENT_{t\sim t+3}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Main results										
PCENTRAL	0.0207***		0.0202***		0.0186***		0.0175***		0.0174***	
	(0.0012)		(0.0014)		(0.0015)		(0.0017)		(0.0017)	
PLOCAL	0.0038***		0.0037***		0.0034**		0.0038**		0.0018	
	(0.0011)		(0.0013)		(0.0014)		(0.0016)		(0.0015)	
PNONSTATE	0.0099***		0.0073***		0.0065***		0.0063***		0.0055***	
	(0.0010)		(0.0012)		(0.0013)		(0.0015)		(0.0014)	
DCENTRAL		0.5527***		0.6161***		0.5737***		0.5107***		0.5619***
		(0.0494)		(0.0549)		(0.0605)		(0.0681)		(0.0648)
DLOCAL		-0.2221***		-0.1228***		-0.0861*		-0.0624		-0.1471***
		(0.0396)		(0.0431)		(0.0471)		(0.0527)		(0.0495)
RDTA	0.2888***	0.2863***	0.2632***	0.2586***	0.2224***	0.2196***	0.1935***	0.1921***	0.2172***	0.2138***
	(0.0111)	(0.0113)	(0.0119)	(0.0121)	(0.0130)	(0.0131)	(0.0146)	(0.0149)	(0.0140)	(0.0142)
ROA	2.0919***	2.2594***	2.5996***	2.7378***	1.9916***	2.1834***	-1.8273***	-1.7267***	-0.0614	0.0446
	(0.3153)	(0.3163)	(0.3898)	(0.3900)	(0.4530)	(0.4542)	(0.4165)	(0.4162)	(0.5041)	(0.5080)
LEVERAGE	0.7294***	0.5175***	0.8581***	0.7159***	0.8046***	0.6849***	0.3572***	0.2477**	0.8100***	0.7251***
	(0.0916)	(0.0913)	(0.1025)	(0.1024)	(0.1127)	(0.1125)	(0.1261)	(0.1260)	(0.1211)	(0.1211)
SIZE	0.3283***	0.3457***	0.2988***	0.3145***	0.3040***	0.3171***	0.3363***	0.3521***	0.3236***	0.3380***
	(0.0082)	(0.0081)	(0.0089)	(0.0088)	(0.0098)	(0.0096)	(0.0120)	(0.0119)	(0.0113)	(0.0111)
TREND	0.0922***	0.0983***	0.0899***	0.0985***	0.1009***	0.1117***	0.1481***	0.1616***	0.2091***	0.2240***
	(0.0073)	(0.0074)	(0.0091)	(0.0092)	(0.0114)	(0.0115)	(0.0145)	(0.0145)	(0.0137)	(0.0136)
Constant	-6.3415***	-6.2786***	-5.6392***	-5.6929***	-5.7162***	-5.7889***	-6.2011***	-6.3491***	-5.2933***	-5.4648***
	(0.1936)	(0.1892)	(0.2155)	(0.2113)	(0.2482)	(0.2437)	(0.3104)	(0.3060)	(0.2969)	(0.2925)
Industry dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Wald chi^2	8198.33***	8060.74***	6590.69***	6497.66***	5293.25***	5227.25***	4110.70***	4055.53***	4684.66***	4653.54***
Obs.	17105	17105	14077	14077	11599	11599	9312	9312	8961	8961

Panel B: Test of equality in coefficients (Chi^2 statistics)

PCENTRAL vs PNONSTATE	96.02***	111.69***	80.11***	54.98***	66.48***	
PLOCAL vs PNONSTATE	44.63***	13.00***	7.77***	3.95***	10.49***	
PCENTRAL vs PLOCAL	242.30***	189.29***	132.87***	86.47***	121.73***	
DCENTRAL vs DNONSTATE	125.07***	125.96***	89.82***	56.16***	75.12***	
DLOCAL vs DNONSTATE	31.47***	8.11***	3.34*	1.4	8.83***	
DCENTRAL vs DLOCAL	251.38***	185.47***	122.81***	75.50***	123.82***	

Notes: This table shows the relationship between ultimate controlling shareholders and innovation performance estimated using Negative Binomial Regression. The first dependent variable (specifications 1-2) is $PATENT_t$, which is measured by the number of patents owned by a company in year *t*. The second dependent variable (specifications 3-4) is $PATENT_{t+1}$, which is measured by the number of patents owned by a company in year *t+1*. The third dependent variable (specifications 5-6) is $PATENT_{t+2}$, which is measured by the number of patents owned by a company in year *t+2*. The fourth dependent variable (specifications 7-8) is $PATENT_{t+3}$, which is measured by the number of patents owned by a company in year *t+3*. The last dependent variable (specifications 9-10) is $PATENT_{t\sim t+3}$, which is measured by the total number of patents owned by a company for 4 years from *t* to *t+3*. *DCENTRAL* is a dummy variable that takes a value of one if a company is ultimately controlled by the central government and zero otherwise. *DLOCAL* is a dummy variable that takes a value of one if a company is ultimately controlled by a local government and zero otherwise. *DNONSTATE* is a dummy variable that takes a value of one if a company is ultimately controlled by a private entity and zero otherwise. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. *RDTA* is measured by the ratio of R&D expenditures to total assets. Firm profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of operating income. Trend (*TREND*) denotes time trend. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses.

Table 7. Innovation (*RDTA-LNPATENT*) and ultimate controlling shareholders – manufacturing industry (Robustness check 4)

	$RDTA_t$		$LNPATENT_t$		$LNPATENT_{t+1}$		$LNPATENT_{t+2}$		$LNPATENT_{t+3}$		$LNPATENT_{t\sim t+3}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Main results												
PCENTRAL	0.0043**		0.0111***		0.0130***		0.0147***		0.0141***		0.0117***	
	(0.0020)		(0.0019)		(0.0022)		(0.0024)		(0.0026)		(0.0024)	
PLOCAL	-0.0002		0.0041**		0.0057***		0.0060***		0.0055**		0.0049**	
	(0.0018)		(0.0017)		(0.0020)		(0.0022)		(0.0024)		(0.0022)	
PNONSTATE	0.0066***		0.0075***		0.0064***		0.0074***		0.0045**		0.0074***	
	(0.0014)		(0.0013)		(0.0015)		(0.0018)		(0.0020)		(0.0017)	
DCENTRAL		-0.0145		0.2500***		0.3779***		0.3960***		0.4318***		0.1995**
		(0.0756)		(0.0728)		(0.0829)		(0.0910)		(0.1003)		(0.0985)
DLOCAL		-0.2118***		-0.0416		0.0231		-0.0453		0.0489		-0.1376*
		(0.0614)		(0.0586)		(0.0671)		(0.0735)		(0.0809)		(0.0764)
RDTA			0.1110***	0.1129***	0.1030***	0.1045***	0.0842***	0.0861***	0.0578***	0.0589***	0.0314***	0.0332***
			(0.0085)	(0.0085)	(0.0097)	(0.0097)	(0.0110)	(0.0109)	(0.0123)	(0.0123)	(0.0085)	(0.0085)
ROA	1.0874***	1.1324***	-0.1006	-0.0415	0.4972**	0.5365***	0.9985***	1.0223***	0.9483***	0.9739***	0.9198***	0.9350***
	(0.1845)	(0.1844)	(0.1602)	(0.1602)	(0.1949)	(0.1948)	(0.2199)	(0.2200)	(0.2768)	(0.2770)	(0.2315)	(0.2318)
LEVERAGE	-0.6500***	-0.7165***	0.2508***	0.1807**	0.1590	0.1004	0.1467	0.0943	-0.0329	-0.0598	0.1218	0.1232
	(0.0978)	(0.0971)	(0.0876)	(0.0873)	(0.1049)	(0.1045)	(0.1203)	(0.1199)	(0.1380)	(0.1373)	(0.1131)	(0.1130)
SIZE	0.0351***	0.0351***	0.0369***	0.0370***	-0.0146	-0.0138	-0.0181*	-0.0165*	-0.023***	-0.0253**	0.0083	0.0098
	(0.0096)	(0.0096)	(0.0085)	(0.0085)	(0.0091)	(0.0091)	(0.0096)	(0.0096)	(0.0105)	(0.0105)	(0.0071)	(0.0071)
TREND	0.1849***	0.1839***	0.1112***	0.1092***	0.0970***	0.0952***	0.0671***	0.0649***	0.0287***	0.0280***	0.2079***	0.2053***
	(0.0046)	(0.0046)	(0.0043)	(0.0043)	(0.0054)	(0.0054)	(0.0068)	(0.0068)	(0.0088)	(0.0088)	(0.0061)	(0.0061)
Constant	-0.2001	0.0794	0.1176	0.4263**	1.3286***	1.5797***	1.5988***	1.8857***	2.2887***	2.4428***	1.3637***	1.6619***
	(0.1982)	(0.1899)	(0.1781)	(0.1700)	(0.1945)	(0.1842)	(0.2100)	(0.1984)	(0.2419)	(0.2300)	(0.1752)	(0.1633)
Industry dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Wald chi2	1944.08***	1913.47***	1522.83***	1481.51***	767.16***	750.88***	328.79***	312.48***	104.46***	94.82***	1626.38***	1608.71***
Obs.	10988	10988	10988	10988	8972	8972	7329	7329	5809	5809	5593	5593

Panel B: Test of equality in coefficients (Chi^2 statistics)

PCENTRAL vs. PNONSTATE	1.72		4.30**		11.77***		12.36***	
PLOCAL vs. PNONSTATE	19.86***		5.47**		0.17		0.61	
PCENTRAL vs PLOCAL	5.52**		14.93***		13.06***		16.14***	
DCENTRAL vs. DNONSTATE		0.04		11.81***		20.78***		18.95***
DLOCAL vs. DNONSTATE		11.89***		0.51		0.12		0.38
DCENTRAL vs DLOCAL		6.36**		15.83***		18.55***		24.18***

PCENTRAL vs. PNONSTATE	17.82***	3.68*	
PLOCAL vs. PNONSTATE	0.26	1.81	
PCENTRAL vs PLOCAL	13.14***	10.44***	
DCENTRAL vs. DNONSTATE		18.54***	4.10**
DLOCAL vs. DNONSTATE		0.37	3.25*
DCENTRAL vs DLOCAL		14.97***	15.16***

Notes: This table shows the relationship between ultimate controlling ownership and innovation performance in manufacturing industry estimated using Tobit regression. The first dependent variable (specifications 1-2) is *RDTA*, which is measured by the ratio of R&D expenditures to total assets. The second dependent variable (specifications 3-4) is $LNPATENT_t$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t*. The third dependent variable (specifications 5-6) is $LNPATENT_{t+1}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+1*. The fourth dependent variable (specifications 7-8) is $LNPATENT_{t+2}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+2*. The fifth dependent variable (specifications 9-10) is $LNPATENT_{t+3}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+3*. The last dependent variable (specifications 11-12) is $LNPATENT_{t\sim t+3}$, which is measured by the logarithm of one plus the total number of patents owned by a company for 4 years from *t* to *t+3*. *DCENTRAL* is a dummy variable that takes a value of one if a company is ultimately controlled by the central government and zero otherwise. *DLOCAL* is a dummy variable that takes a value of one if a company is ultimately controlled by a local government and zero otherwise. *DNONSTATE* is a dummy variable that takes a value of one if a company is ultimately controlled by a private entity and zero otherwise. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. Firm profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of operating income. Trend (*TREND*) denotes time trend. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses.

Table 8. Innovation (*RDTA-LNPATENT*) and ultimate controlling shareholders - non-manufacturing industry (Robustness check 5)

	$RDTA_t$		$LNPATENT_t$		$LNPATENT_{t+1}$		$LNPATENT_{t+2}$		$LNPATENT_{t+3}$		$LNPATENT_{t\sim t+3}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Main results												
$PCENTRAL_t$	-0.0055**		0.0081***		0.0106***		0.0133***		0.0153***		0.0094***	
	(0.0027)		(0.0020)		(0.0021)		(0.0023)		(0.0025)		(0.0029)	
$PLOCAL_t$	-0.0083***		0.0004		-0.0002		0.0017		0.0024		-0.0009	
	(0.0022)		(0.0015)		(0.0017)		(0.0018)		(0.0019)		(0.0021)	
$PNONSTATE_t$	-0.0013		0.0030**		0.0032*		0.0047**		0.0035*		0.0006	
	(0.0021)		(0.0015)		(0.0017)		(0.0018)		(0.0020)		(0.0023)	
$DCENTRAL_t$		-0.2881***		0.1447*		0.2385***		0.3123***		0.4011***		0.1778
		(0.1044)		(0.0771)		(0.0847)		(0.0891)		(0.0973)		(0.1156)
$DLOCAL_t$		-0.3846***		-0.1306**		-0.181***		-0.1447**		-0.0778		-0.2009**
		(0.0811)		(0.0601)		(0.0665)		(0.0692)		(0.0752)		(0.0920)
RDTA			0.0700***	0.0692***	0.0502***	0.0496***	0.0402***	0.0391***	0.0100	0.0093	0.0473***	0.0471***
			(0.0082)	(0.0082)	(0.0087)	(0.0087)	(0.0095)	(0.0095)	(0.0111)	(0.0111)	(0.0099)	(0.0099)
ROA_t	0.6503**	0.5924**	-0.0300	0.0134	0.0253	0.0654	0.0790	0.1556	0.3284	0.4232	0.2403	0.2316
	(0.2979)	(0.2963)	(0.1874)	(0.1864)	(0.2353)	(0.2343)	(0.2570)	(0.2550)	(0.3006)	(0.2979)	(0.3513)	(0.3482)
$LEVERAGE_t$	-0.6850***	-0.6495***	0.2194**	0.2342**	0.1790*	0.2000*	0.0767	0.0966	-0.0450	-0.0125	0.1359	0.1709
	(0.1409)	(0.1412)	(0.0933)	(0.0937)	(0.1068)	(0.1073)	(0.1173)	(0.1180)	(0.1305)	(0.1314)	(0.1344)	(0.1346)
$SIZE_t$	0.0443***	0.0428***	0.0379***	0.0408***	0.0171*	0.0199**	0.0042	0.0080	-0.0152	-0.0106	0.0129	0.0144
	(0.0139)	(0.0137)	(0.0090)	(0.0089)	(0.0094)	(0.0093)	(0.0095)	(0.0095)	(0.0102)	(0.0102)	(0.0091)	(0.0091)
TREND	0.0778***	0.0764***	0.0608***	0.0601***	0.0600***	0.0596***	0.0474***	0.0480***	0.0320***	0.0336***	0.1154***	0.1152***
	(0.0065)	(0.0065)	(0.0041)	(0.0041)	(0.0050)	(0.0050)	(0.0060)	(0.0060)	(0.0075)	(0.0075)	(0.0067)	(0.0067)
Constant	-0.3818	-0.3552	-0.659***	-0.575***	-0.2419	-0.1414	0.0495	0.1666	0.6762***	0.7187***	-0.0278	0.0403
	(0.3030)	(0.2958)	(0.2034)	(0.1989)	(0.2236)	(0.2186)	(0.2335)	(0.2290)	(0.2601)	(0.2560)	(0.2634)	(0.2581)
Industry dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Wald chi2	1100.86***	1112.25***	647.16***	633.03***	473.90***	460.00***	347.42***	327.70***	287.24***	262.53***	554.42***	551.24***
Obs.	6117	6117	6117	6117	5105	5105	4270	4270	3503	3503	3368	3368

Panel B: Test of equality in coefficients (Chi^2 statistics)

PCENTRAL vs. PNONSTATE	3.02*		7.90***		13.92***		17.04***		27.45***		10.29***	
PLOCAL vs. PNONSTATE	13.82***		3.68*		5.00**		3.51*		0.40		0.50	
PCENTRAL vs PLOCAL	1.50		19.96***		33.06***		35.44***		37.70***		17.28***	
DCENTRAL vs. DNONSTATE		7.62***		3.52*		7.93***		12.27***		17.00***		2.37
DLOCAL vs. DNONSTATE		22.52***		4.72**		7.42***		4.38**		1.07		4.77**
DCENTRAL vs DLOCAL		0.89		13.21***		26.04***		28.80***		27.29***		13.07***

Notes: This table shows the relationship between ultimate controlling ownership and innovation performance in non-manufacturing industry estimated using Tobit regression. The first dependent variable (specifications 1-2) is *RDTA*, which is measured by the ratio of R&D expenditures to total assets. The second dependent variable (specifications 3-4) is $LNPATENT_t$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t*. The third dependent variable (specifications 5-6) is $LNPATENT_{t+1}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+1*. The fourth dependent variable (specifications 7-8) is $LNPATENT_{t+2}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+2*. The fifth dependent variable (specifications 9-10) is $LNPATENT_{t+3}$, which is measured by the logarithm of one plus the number of patents owned by a company in year *t+3*. The last dependent variable (specifications 11-12) is $LNPATENT_{t\sim t+3}$, which is measured by the logarithm of one plus the total number of patents owned by a company for 4 years from *t* to *t+3*. *DCENTRAL* is a dummy variable that takes a value of one if a company is ultimately controlled by the central government and zero otherwise. *DLOCAL* is a dummy variable that takes a value of one if a company is ultimately controlled by a local government and zero otherwise. *DNONSTATE* is a dummy variable that takes a value of one if a company is ultimately controlled by a private entity and zero otherwise. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. Firm profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of operating income. Trend (*TREND*) denotes time trend. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses.

5. Conclusion

This study attempts to investigate the impacts of ownership structure reform on the innovation performance of a large sample of listed firms in China during the 2007–2015 period. We highlight the importance of identifying the ultimate controlling shareholders in investigating the ownership-innovation nexus and categorize China's listed firms into SOEs controlled by the central government, SOEs controlled by the local government, and firms controlled by non-state investors by tracing the identity of their ultimate controlling shareholders. We echo Belloc's (2014) proposition on reconsidering the conventional wisdom concerning SOEs and argue that non-state ownership of listed firms in China is not necessarily superior to certain types of state ownership because different types of ultimate controlling shareholders possess various objectives, motivations, resources, and capabilities that will influence how they exercise their control rights over the firms they invest in. In particular, we examine the impacts of three different types of ultimate controlling ownership on both input- and output-oriented measurements of corporate innovation activities. The empirical results suggest that R&D intensity is most strongly associated with non-state controlling ownership, whereas the "national champions", SOEs controlled by the central government, have the strongest performance in innovation outputs. Local-government controlling ownership appears to be the weakest player in terms of both innovation inputs and outputs. The findings are robust to various model specifications and support both hypotheses.

In general, our findings provide rough support for Stiglitz's (1999) argument that, in a country with relatively weak institutional environments, such as China, market-oriented state shareholders might be firms' most suitable controlling owners. The findings also echo the argument of Belloc (2014), who indicates that SOE inefficiency is not due to state ownership *per se* but is rather caused by conditions to which SOEs often relate. Specifically, our findings

lend support to the Chinese government's selective privatization strategy and suggest that the state should not shrink itself to residuals in the current wave of innovation in China. Instead, the "national champions" should team up with the vigorous non-state sector and become key enablers of China's plan to encourage indigenous innovation. In addition, the Chinese government should carefully revisit its innovation policy concerning local-government controlling ownership because this group suffers from lower incentives, poor monitoring, and fewer external resources for innovation.

Although this paper is the first to use a large dataset to investigate the different impacts of various shareholders on corporate innovation in China, the empirical analysis remains subject to empirical limitations and drawbacks, which could be considered new research opportunities. For example, both the R&D intensity ratio and the number of patents obtained are quantitative measurements of innovation; neither reflects the quality of corporate innovation activities. Therefore, future research should adopt quality indicators of innovation performance, such as new product introduction. In addition, this study focuses on listed firms in China. Its findings might not be valid for non-listed firms. Thus, future research could expand the sample set by including both listed and non-listed firms to better understand the mechanism between ownership structure and innovation in China.

Acknowledgements

The authors are grateful for funding from the University of Macau (Grant reference no.: MYRG2016-00213-FBA) and The Science and Technology Development Fund and National Natural Science Foundation of China (FDCT-NSFC grant reference no:0037/2018/AFJ). We appreciate the comments from participants of the 2016 Research Workshop co-organized by the Technology and Management Centre for Development and the Said Business School in the University of Oxford, 30th Australasian Finance and Banking Conference, and 2019 New Zealand Finance Meeting. All errors of course rest with the authors.

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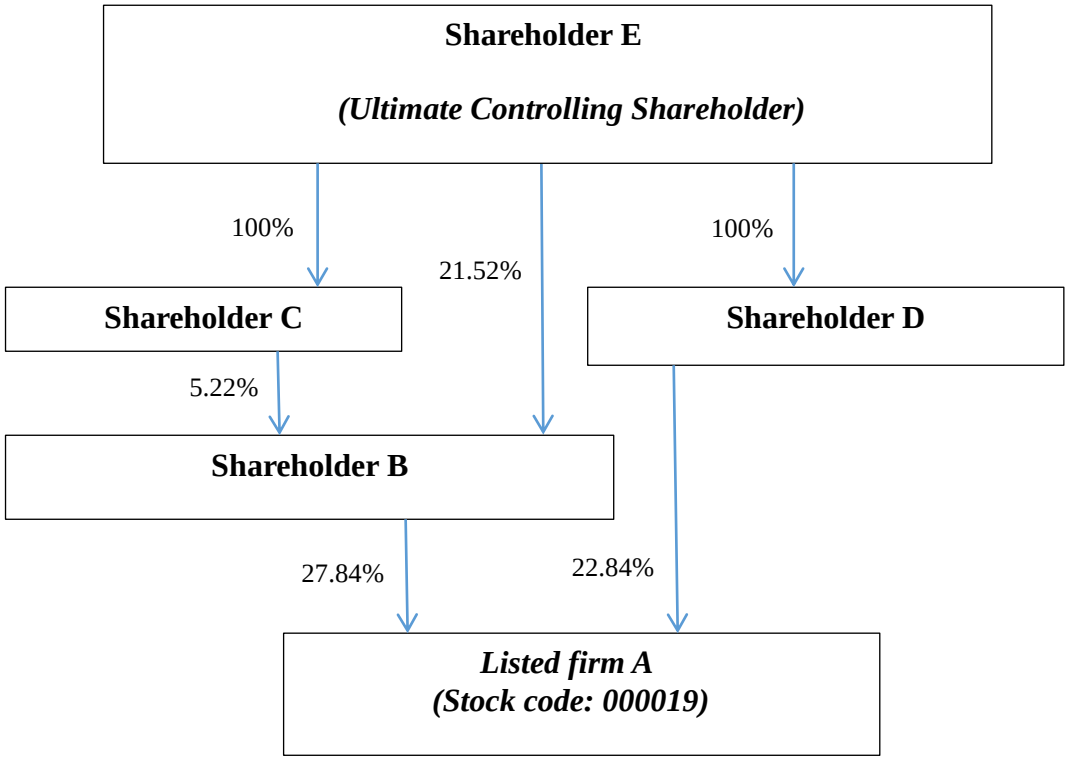
Appendix A. Ultimate controlling ownership

To calculate a listed firm's ultimate controlling ownership, we follow La Porta et al. (1999) and Faccio and Lang (2002) by combining the shareholder's direct and indirect voting rights in the firm and summing the weakest layer in each chain of control. Please see the chart below for an example.



This example has three shareholding relation chains: (1) E-C-B-A, (2) E-B-A, and (3) E-D-A. The weakest layers of these shareholding relation chains are 5.22%, 21.52%, and 22.84%, respectively. Therefore, Shareholder E's ultimate controlling ownership (i.e., the percentage of voting rights held by ultimate controlling shareholder E) of the listed firm A is equal to 49.58% (5.22% + 21.52% + 22.84%).

Appendix B. Correlation matrix

	LNPATENT	*RDD*	*RDOI*	*RDTA*	*DCENTER*	*DLOCAL*	*DNONSTATE*	*PCENTER*	*PLOCAL*	*PNONSTATE*	*SIZE*	*ROA*	*LEVERAGE*
RDD	0.456***												
RDOI	0.253***	0.392***											
RDTA	0.379***	0.496***	0.760***										
DCENTER	0.076***	-0.017**	-0.042***	-0.023***									
DLOCAL	-0.162***	-0.250***	-0.223***	-0.234***	-0.272***								
DNONSTATE	0.095***	0.242***	0.235***	0.233***	-0.459***	-0.730***							
PCENTER	0.097***	-0.004	-0.047***	-0.021***	0.933***	-0.254***	-0.429***						
PLOCAL	-0.144***	-0.228***	-0.209***	-0.217***	-0.247***	0.908***	-0.663***	-0.230***					
PNONSTATE	0.126***	0.251***	0.213***	0.213***	-0.392***	-0.623***	0.854***	-0.366***	-0.566***				
SIZE	0.194***	-0.015*	-0.186***	-0.063***	0.204***	0.175***	-0.307***	0.248***	0.199***	-0.238***			
ROA	0.076***	0.068***	0.061***	0.137***	-0.051***	-0.076***	0.106***	-0.040***	-0.040***	0.142***	0.039***		
LEVERAGE	-0.097***	-0.247***	-0.322***	-0.275***	0.149***	0.239***	-0.326***	0.148***	0.201***	-0.327***	0.386***	-0.343***	
TREND	0.190***	0.380***	0.225***	0.252***	-0.067***	-0.137***	0.173***	-0.059***	-0.113***	0.178***	0.063***	-0.040***	-0.076***

Notes: Firm patents (*PATENT*) are measured by the number of patents owned by a company. *LNPATENT* is the logarithm of one plus the number of patents owned by a company. R&D decision (*RDD*) is a dummy variable that takes a value of one if a company has positive R&D expenditures and zero otherwise. *RDOI* is measured by the ratio of R&D expenditures to operating income. *RDTA* is measured by the ratio of R&D expenditures to total assets. *DCENTRAL* is a dummy variable that takes a value of one if a company is ultimately controlled by the central government and zero otherwise. *DLOCAL* is a dummy variable that takes a value of one if a company is ultimately controlled by a local government and zero otherwise. *DNONSTATE* is a dummy variable that takes a value of one if a company is ultimately controlled by a private entity and zero otherwise. *PCENTRAL* and *PLOCAL* denote the percentages of ultimate central and local government ownership, respectively. *PNONSTATE* is the percentage of ultimate private ownership. Firm profitability (*ROA*) is measured by return on assets. Firm leverage (*LEVERAGE*) is measured as the ratio of the book value of total liabilities to the book value of total assets. Firm size (*SIZE*) is measured by the logarithm of operating income. Trend (*TREND*) denotes time trend.