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Public governance, corporate governance, and firm innovation: An examination of state-owned enterprises

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Abstract
Innovation activities create substantial firm value, but they are difficult to manage owing to agency risk which is commonly thought to result in shirking, hence underinvestment in innovation. However, agency risk can also create inefficient allocation of resources among innovation activities, on which the literature provided limited understanding. We examine an important outcome created by agency risk—that agents pursue the quantity of innovation at the expense of the novelty, and investigate how it is influenced by corporate and public governance. We theorize that improved corporate governance tools, including better alignment of agents' private incentives and stronger monitoring, and high-quality public governance reduce such agency risk in state-owned enterprises (SOEs). Furthermore, higher-quality public governance enhances the functioning of corporate governance tools in further reducing such agency risk in innovation. We test our theory in the context of Chinese SOEs that responded to state's pro-innovation policies relying disproportionately on quantifiable outcomes (e.g., patent counts) for assessing innovation performance. Our difference-in-differences estimates provide overall support for the hypotheses. These findings provide new insights on how agency risk affects innovation by distinguishing the consequences on quantity and novelty of innovation and on how conventional corporate governance tools shaping innovation is dependent on public governance.

Keywords
Corporate governance, public governance, innovation, quality of government, state-owned enterprises (SOEs)

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Despite their tremendous value to firms, innovation activities are difficult to manage because they entail considerable uncertainties and information asymmetry (Baysinger, Kosnik, & Turk, 1991; Lee & O'Neill, 2003). These conditions create a fertile ground for agency risk (Eisenhardt, 1989). Extant studies leveraged agency theory to examine how corporate governance tools, such as incentive alignment and monitoring, reduce shirking among agents (Cohen & Levin, 1989; Zenger, 1994), thereby alleviating underinvestment problems in innovation activities (e.g., Kochhar & David, 1996; Hoskisson, Hitt, Johnson, & Grossman, 2002; David, O'Brien, & Yoshikawa, 2008). However, increased inputs invested in innovation activities alone do not necessarily generate greater firm value. He and Wang (2009) and Zhou, Gao, and Zhao (2017) argued that agency risk also reduces the efficiency of deploying invested resources in innovation activities. Despite this important observation, extant research has provided limited understanding of how such inefficiency could occur.

We draw on the multitasking model to examine a specific type of agency risk that can create such inefficiency. We focus on the moral hazard that certain agents pursue the quantity of innovation which is more-readily captured by objective metrics used to evaluate these agents, at the expense of the novelty of innovation which is less-well captured by these evaluation metrics. This is a meaningful topic to explore because novel innovation contributes to a firm's innovative capability, competitive advantages and long-term survival, such that overlooking novel innovation diverges from optimal firm value (Katila 2000, Mitchell 1989).

We examine how corporate and political governance tools reduce this type of moral hazard that threatens to upset the balance between the quantity and the quality of innovation. We first examine how conventional corporate governance tools including aligning agents' incentives with firm value and monitoring reduce this moral hazard, thereby shaping the balance between the quantity and the novelty of innovation. We further examine how the broader institutional context—the quality of public governance (also known as the quality of government, see Weber, 1968) in the political system affects the accountability of principals of state-owned enterprises (SOEs), thereby influencing the moral hazard and firms' innovation outcomes. We finally examine a mutually reinforcing effect between corporate and political governance.

To test our theory, we examine publicly listed Chinese SOEs between 2000 and 2012, which constitutes a suitable research context for the following reasons. First, this context offers an opportunity to observe the conditions that prompt agents to pursue the quantity in innovation at the expense of the novelty. In 2006, the Chinese government initiated a major policy change to reward domestic firms for indigenous innovation. The state designed detailed and actionable plans to produce a certain number of domestic patents. However, the policy specified very limited actionable checks on the quality or novelty of those patents. The policy was applicable to all firms, but it had particularly strong implications for SOEs. The state also acted as the principal of SOEs. Thus, by implementing this policy, the state directly established evaluation metrics to be used for assessing the innovation activities of SOE agents. (By contrast, the principals of privately owned enterprises may or may not adopt the same metrics to incentivize their agents, depending on how much they decide to respond to the call of the state.) These metrics enabled agents to make certain tradeoffs between the quantity and the novelty in developing innovation. Second, certain SOEs face greater agency risk than others because of the substantial variation in the corporate governance, including the degree of incentive alignment and monitoring (Xu, 2011). Finally, extensive disparity exists in the quality of public governance across different regions in China (Xu, Tihanyi, & Hitt, 2017; Jia, 2014). Therefore, studying the response of Chinese SOEs to the state's innovation policy allows us to separately and jointly examine our theory about the effects of corporate and public governance on firms' innovation outcomes.

This study offers the following key contributions. First, we introduce a different, important, and yet understudied type of agency risk to the innovation management literature compared with the common concerns over agents' underinvestment in innovation (Cohen & Levin, 1989; Zenger 1994; Kochhar & David, 1996; Hoskisson et al., 2002). This new theoretical angle allows us to diverge from the unidimensional outcome of "more or less" innovation to examine the quantity of innovation and the proportion of novel innovation. The innovation literature has examined the novelty of technologies, but the conventional perspective was that novelty was a matter of firm choice, that is, either firms intentionally chose to develop less-novel incremental technologies or certain firms developed more-novel technologies (such as to disrupt other firms, e.g., Mitchell, 1989, Henderson & Clark, 1990). We demonstrate that this outcome may not always have been created intentionally, but it can be generated by agency risk and improper use of governance tools.

Second, we contribute to the corporate governance literature the theoretical view that aside from the corporate governance of agents (the predominant focus in prior studies), the accountability of the principal can also effectively shape the innovation outcomes of firm. Extant research finds that the broader social-economic context can affect corporate governance (Greve & Zhang, 2017), including the degree to which principals hold agents accountable. Specifically, national traditions in terms of prevailing ownership types, national value, and governance logics influence the extent of managerial discretion of firms in the nation (e.g., Crossland & Hambrick, 2007; Crossland & Chen, 2013; Desender, Aguilera, Lópezpuertas-Lamy, & Crespi, 2016). We examine how a core feature of the political system, namely, the quality of public governance, also shapes the functioning of the state principals of SOEs. Moreover, we found that good corporate governance generates a more notable effect on firm innovation outcomes in the presence of higher-quality public governance. Therefore, the effect of corporate governance on innovation is influenced by the institutional context, which further supports the call for gaining more understanding into the institutional contexts of agency theory (e.g., Aguilera et al., 2015).

Third, this study also addresses a key tension in the research of state capitalism, namely, a state's involvement in commercial enterprises (e.g., Zhou et al., 2017). Some research argued that the state's long-term orientation would foster innovation in SOEs (e.g., Munari, Oriani, & Sobrero, 2010; Choi, Lee, & Williams, 2011), whereas others questioned the state's capability to manage innovation (e.g., Hart, Shleifer, & Vishny, 1997; Shleifer, 1998). We demonstrate that while the active intention of the state to promote innovation can indeed increase the overall amount of innovation, it remains a tricky task for the state to ensure the balance pertaining to the quantity and the novelty of innovation.

Finally, this study sheds new light on the important context of innovation in China. Despite increasing scholarly and public policy interest in the process and outcome of innovation in China (e.g., Abrami, Kirby, & McFarlan, 2014; Huang, 2010; Huang, Geng, & Wang, 2017), there exists much speculation about the quality and the quantity of innovations developed there based on anecdotes. This study is among the first to examine the balance between the quantity and the novelty of innovation in Chinese SOEs, particularly through the lens of agency risk.

THEORY AND HYPOTHESES

Theoretical Background: Agency Risk in Innovation

Many agents in firms play critical roles in developing technological innovation. These agents include not only the technical personnel who directly participate in innovation activities such as scientist and engineers (Huang, 2017; Huang & Ertug, 2014), but also those who make strategic decisions to substantially shape innovation outcomes, such as the board of directors and firm managers (Damanpour, 1991; He & Wang, 2009). In this paper, we focus on firm managers and board of directors because they make strategic decisions that influence the processes in which innovation is pursued or terminated, the resources allocated among R&D activities, and the internal evaluation metrics used to evaluate and reward innovation outcomes (Zaltman, Duncan, & Holbek, 1973). To enable these agents to further the firm's interests and create value by generating innovation, they must have sufficient capabilities and right incentives (Lee & O'Neill, 2003).

Providing the right incentives to firm agents to engage in innovation is challenging for two reasons. First, innovation requires highly uncertain and complex tasks, such that the outcomes are confounded both by agents' own efforts and by factors that are beyond the control of agents and firms (Lippman & Rumelt, 1982). Second, innovation generates greater information asymmetry because it confers greater private information and generates proprietary information that managers are unwilling to communicate with mass investors (Bebchuk & Stole, 1993). Directly observing agents' efforts in the case of developing innovation or accomplishing tasks that help build innovative capabilities is difficult and often impossible; hence, a common approach for providing proper incentives is for principals to use alternative metrics to evaluate performance outcomes of agents (Gibbons, 2005).

In innovation, certain metrics for assessing how well agents promoted firms' innovation are more objective and less noisy. The most common metrics include quantifying observable innovation outcomes (e.g., counting patents). By contrast, other measures tend to be more subjective and noisier, such as measures of the quality or novelty of innovation. Innovation exhibits large variance in their level of novelty; thus, the economic value of innovation is highly heterogeneous (Cohen & Levin, 1989). Novel innovation often helps build and enhance a firm's innovative capability by enhancing the firm's performance and competitive advantage (Katila, 2000; Mitchell, 1989). Indeed, in many technology industries, certain incumbents generate incremental improvements and follow their core technologies to obsolescence and obscurity, whereas firms that can generate novel and breakthrough innovation can become new industry leaders (e.g., Mitchell, 1989; Henderson & Clark, 1990). Therefore, novel innovation has greater potential to achieve higher long-term value for firms than incremental innovation, it is also more costly and riskier to develop. Despite the value of novel innovation, the evaluation of the novelty of innovation inevitably entails a larger subjective component and contains greater noise.

Principals, particularly less informed principals, often rely heavily on objective, quantifiable, and less-noisy metrics of quantifying innovation outcomes than more subjective and noisier metrics of assessing the novelty of innovation, wherein the latter elicits two major concerns. The first concern is that principals, who commonly do not directly participate in the process of developing innovation, possibly lack the capabilities and information to accurately assess the novelty of innovation (e.g., Kor & Mahoney, 2005; He & Wang, 2009), which will increase noise in the measurement (Feltham & Xie, 1994). This noise will feed into the noise in the correlation between the compensation paid to agents and their actual efforts; thus, agents are less likely to exert efforts ex ante (Gibbons, 2005). The second concern arises from an adverse outcome that would be created when agents are concerned about an inherent infringement hazard due to a lack of credible commitment in subjective evaluation. Specifically, principals who use subjective evaluation metrics will have incentives to give agents low evaluation and thus underpay them after agents invest efforts in developing innovation, in anticipation of which agents will underinvest ex ante (e.g., Gibbons, 1987; 2005).

This metric adoption, however, engenders a common type of moral hazard expressed as "you get what you pay for" (Kerr, 1975); this concept is theorized by the multitasking model (Holmstrom & Milgrom, 1991) as follows: Agents exert greater efforts in activities where outcomes are captured by a certain type of evaluation metrics than in other activities whose outcomes are not captured by the focal metrics. Meanwhile, agents disregard the possibility that over-pursuing activities captured by the focal metrics may harm long-term firm value, and they ignore the prospect that activities that are not captured by the focal metrics (which thus receive insufficient investment from them) would have contributed to firm value (Baker, 1992; Lambert, Larcker, & Weigelt, 1993; Gibbons, 1998; for a review, see, e.g., Predergast, 1999; Gibbons, 2005).

Therefore, when principals adopt the more-objective and less-noisy metrics of quantifying innovation, the multitasking model predicts that agents whose private interests are not aligned with firm value will prioritize the generation of a larger quantity of innovation, but they will not prioritize the production of novel innovation captured by more subjective and noisier metrics—even though such innovation would have increased firm value. The greater the extent to which agents overinvest in incremental innovation and underinvest in novel innovation, the further they diverge from the optimal firm value because a more balanced mix of incremental and novel innovation helps build greater firm innovation capabilities and create higher firm value, according to the theory on balancing exploration and exploitation in firm innovation (e.g., Katila and Ahuja, 2002). How much agents care about this divergence from optimal value is shaped by corporate and public governance, which will be discussed next.

Effects of Corporate Governance on Firm Innovation

Two key corporate governance practices determine managerial agency risk in modern firms: (1) the use of governance tools to align the private incentives of agents more closely with firm value and (2) the use of monitoring by owners (Shleifer & Vishny, 1997; He & Wang, 2009; Desender et al., 2016; Misangyi & Acharya, 2014). We study each one in turn.

When agents are given greater private incentives in accordance with firm value, they should have a greater personal stake in preserving or enhancing firm value. When the principal starts to evaluate the performance of innovation primarily by quantifying innovation outcomes, a closer alignment of the agents' private interest and the firm value will augment the behavior of agents compared with the predictions made based on the multitasking model by changing the agent's consideration of the costs of developing innovation.

The costs of simply producing any innovation are not the same for all agents. They tend to be higher for agents whose interests are more aligned with firm value than for agents whose interests are less aligned with firm value. These costs mainly take the form of the opportunity costs of foregoing other value-enhancing activities to (over)produce innovation. Some fungible resources (e.g., financial resources) devoted to such activities may otherwise be invested in other undertakings that could offer greater contribution to firm value; thus, compared with alternative uses of these resources, certain innovation generates less value for firms (Cockburn, 2004). Therefore, agents whose private interests are more closely aligned with firm value will exercise more checks and greater scrutiny on the opportunity costs of producing innovation than agents whose interests are less aligned with firm value.

Consequently, when the principal evaluates agents based on quantifying innovation outcomes, the agents whose interests are completely aligned with firm value will avoid promoting innovation at any cost. However, agents who do not share the interest of achieving higher firm value will decide otherwise because they are simply rewarded by the principal for producing additional innovation, but they do not bear the associated opportunity costs. Therefore, we hypothesize the following:

> ***H1a**: When principals adopt metrics that rely on quantifying innovation outcomes, firms whose agents' private interests are more aligned with firm value will generate a smaller quantity of innovation than firms where this alignment is weak.*

Second, fungible resources can be used to develop different innovation projects. Highly novel technologies are costly to develop because novel innovation frequently take longer to create, are riskier to develop, and have higher failure rates than general technologies (Fleming, 2001, 2007). However, metrics that simply quantify innovation outcomes without assessing novelty will not reward a more novel innovation differently from a less novel one. In particular, the private benefits of agents whose interests (e.g., personal, financial, and career) are less aligned with firm value for developing novel innovation arise more from the principal's rewards and less from changes in firm value. Thus, these agents do not derive significant private benefits from developing more-novel innovation than from developing less-novel innovation because the principal's reward metrics make minimal distinction between incremental and novel innovation. Therefore, these agents have little reason to produce costlier and riskier novel innovation and they are likely to develop less-costly incremental innovation. This incentive will directly affect the proportion of novel innovation among all new innovation produced by the focal firm. That is, in response to the principals' evaluation metrics of quantifying innovation outcomes without assessing the novelty of innovation, agents whose interests diverge from firm value will produce a smaller proportion of novel innovation.[1] Therefore, we offer the following hypothesis:

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[1] Some research argued that giving agents higher financial incentives could lead to greater risk aversion (e.g. Beatty & Zajac, 1994; Goranova, Alessandri, Brandes, & Dharwadkar, 2007). Because certain novel innovation is risky to develop, this argument would suggest an outcome that counteract H1b. We acknowledge this theoretical possibility.

***H1b**: When principals adopt metrics that rely on quantifying innovation outcomes, firms whose agents' private interests are more aligned with firm value will generate a larger proportion of novel innovation relative to all the innovation produced by the focal firm than firms where this alignment is weaker.*

The second determinant of agency risk is the degree of monitoring performed by the principal. When principals more effectively monitor the actions of agents, the latter tend to exert greater effort that approaches the optimal level for firm value (e.g., Hart & Holmstrom, 1986); thus, the misaligned incentives and associated moral hazard discussed above are less likely to occur (Gibbons, 2005). The ultimate goals of principals in promoting innovation commonly entail enhancing firm innovativeness. Through closer monitoring and supervision, a principal is more likely to detect and correct the agents' actions of gaming the metrics that cannot be justified from a firm value perspective, such as that of accelerating the production of less-novel innovation at the expense of novelty and possibly at the cost of other value-enhancing activities. Therefore, we offer the following theoretical predictions.

***H2a**: When principals adopt metrics that rely on quantifying innovation outcomes, firms with stronger monitoring of their agents will generate a smaller quantity of innovation than firms with weaker monitoring.*

***H2b**: When principals adopt metrics that rely on quantifying innovation outcomes, firms with stronger monitoring of their agents will generate a larger proportion of novel innovation relative to all the innovation produced by the focal firm than firms with weaker monitoring.*

Effects of Public Governance on Firm Innovation

A distinctive feature of SOEs is that their principals, namely, governments, do *not* always act in the best interest of the public whom they are supposed to represent (Zhou et al., 2017). How well a government performs its functions, including the function of acting as principals of SOEs

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To the extent that the empirical results lend strong support for H1b, we consider the core arguments above to be more predominant. We thank an anonymous reviewer for raising this point.

to advance the value of state assets in those firms, are determined by the quality of government (North, 1981; Acemoglu & Johnson, 2005; La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1999).

What constitutes a high-quality government? A fundamental theory that profoundly influenced the understanding of governments in multiple disciplines, including political science, sociology, and economics, was developed by Weber (1968). In the Weberian tradition, high-quality governments are more strongly characterized by a modern legal rational public governance system than a pre-modern patrimonial governance system. A legal rational governance system is bounded by impersonal rules, relies on hierarchy and meritocracy, stays politically neutral, and compensates civil servants based on salary. In a legal rational governance system, government officials do not have the right to extract rents from private citizens. By contrast, a patrimonial governance system relies heavily on loyalty in governance and gives licenses to officials to extract "prebends" from the citizens as legitimate compensation for their service.

Scholars across multiple disciplines have reached wide consensus that under high-quality public governance along the Weberian principles, public officials diligently perform the functions of government and are highly restrained from extracting from the general public, which fosters economic development (e.g., Polanyi, [1944] 1957; Evans, 1995; Knack & Keefer, 1995; Evans & Rauch, 1999; Rauch & Evans, 2000; La Porta et al., 1999; Johnson, 1982; Amsden, 1990; Wade, 1990).

Therefore, under high-quality public governance, public officials of relevant government branches more diligently perform the role of the state as principals of SOEs, which is to promote the value of SOEs. Faced with insufficient information on the agents' actions (such as those related to innovation), a key task that a principal can undertake is to collect additional information, which, despite the imperfection and incompleteness, will improve the welfare of the principal

(Holmstrom, 1979; for a review, see Shleifer & Vishny, 1997). For example, the principal can create new systems of information collection and make better use of available information about agents' actions and external factors that affect firm outcomes (Holmstrom, 1979). This additional information will help the principal design governance tools that effectively align the agents' incentives with firm value and/or reduce the agency risk.

Conversely, under low-quality public governance, government officials are generally held less accountable for advancing the state's interests. Thus, public officials responsible for exercising the role of SOE principals can shirk their responsibilities, such as by ignoring actions needed to enhance the SOEs' value, including information collection. Consequently, SOE agents have increased opportunities to get away with actions that game the metrics and that fail to advance or even harm the value of SOEs. Therefore, agency risk in SOEs is lower in the presence of high-quality governments and agents of these SOEs are less likely to engage in moral hazard in innovation. We then propose the following hypotheses.

> ***H3a****: When principals adopt metrics that rely on quantifying innovation outcomes, SOEs governed by a higher-quality government will generate a smaller quantity of innovation than SOEs governed by a lower-quality government.*

> ***H3b****: When principals adopt metrics that rely on quantifying innovation outcomes, SOEs governed by a higher-quality government will generate a larger proportion of novel innovation relative to all the innovation produced by the focal firm than SOEs governed by a lower-quality government.*

Interdependent Effects of Corporate and Public Governance on Firm Innovation

The mechanisms of corporate governance for agents and those of public governance for principals (identified here as state principals) do not work independently from each other in affecting the innovation outcomes of SOEs. A less informed state principal (i.e., one that collects less information on agents' actions) is less capable of distinguishing the degree to which agents' actions have contributed to certain firm outcomes, as opposed to external factors that are outside the agents' control (e.g., luck). Although it is commonly known that innovation activities are inherently uncertain and risky because of factors beyond the agents' control, precisely estimating the degree of such uncertainty and risk is extremely difficult for uninformed parties. Thus, a less-informed principal is more likely to fail to sufficiently reward agents for their productive actions and/or punish agents disproportionately for innovation outcomes that are primarily influenced by factors outside the agent's control.

However, this inefficiency does not affect all agents equally. While it might be ambiguous as to whether mistakes made by less-informed principals would benefit or harm the agents whose interests and actions have diverged from the firm value, it is in the best interest of agents who more diligently work to contribute to firm value to have a more informed principal to better identify and, thus, reward their efforts rather than, for example, a principal using the population average, which also includes less-diligent agents to make generic inferences about the efforts of more-diligent agents. As shown by Holmstrom (1979), the welfare of both principals and agents can be improved when principals collect additional information on agents.

Therefore, when high-quality public governance prompts the state principal to more diligently collect information on SOE agents' actions, agents who more diligently work toward firm value (owing to higher-quality corporate governance) are likely to support information collection efforts, such as by interacting more intensely with the state principal to facilitate the information collection process. This outcome suggests that under high-quality public governance, corporate governance further reduces the perverse innovation outcomes that would have been produced by the moral hazard of agents. Stated alternatively, the relationships between corporate governance tools and

SOE innovation outcomes (as theorized in H1a, H1b, H2a, and H2b) will be more pronounced in the presence of higher quality public governance. Thus, we develop the following hypotheses.[2]

> ***H4a****: The effect predicted by H1a is stronger for SOEs governed by a higher-quality government than for SOEs governed by a lower-quality government.*

> ***H4b****: The effect predicted by H1b is stronger for SOEs governed by a higher-quality government than for SOEs governed by a lower-quality government.*

> ***H4c:*** *The effect predicted by H2a is stronger for SOEs governed by a higher-quality government than for SOEs governed by a lower-quality government.*

> ***H4d:*** *The effect predicted by H2b is stronger for SOEs governed by a higher-quality government than for SOEs governed by a lower-quality government.*

Figure 1 summarizes the theoretical framework described above.

Insert Figure 1 About Here

RESEARCH CONTEXT

To examine our hypotheses, we utilize an exogenous top-down innovation policy that can serve as a quasi-experiment in the context of China. China follows a state capitalism model wherein the state plays a direct role in promoting and influencing economic development through reform policies (e.g., Zhang & Greve, 2016) and uses SOEs as an important channel to influence the economy and society (e.g., Xu, 2011). In recent years, the state has actively promoted

[2] We acknowledge that public and corporate governance can act as substitutes—but under very different circumstances. For example, if a particular public governance mechanism allows or forces the state principal more directly to make decisions for the SOEs on specific activities (such as allocating resources and personnel to different innovation projects and starting/terminating various projects) and overrule the decisions made by agents on those issues, then this public governance mechanism will weaken the agents' discretion with respect to such activities, thereby making agents' actions less relevant to innovation outcomes. When this happens, corporate governance mechanisms that aim to influence agents' behavior will also become less relevant to (i.e., exert less effect on) innovation outcomes. This hypothetical scenario will constitute a substitution effect. However, such scenario is less likely to hold in our research context, particularly with respect to SOEs. Politicians responsible for managing state assets in SOEs commonly lack the technical knowledge that would enable them to make specific decisions regarding operational issues in innovation development (Hart et al., 1997; Shleifer, 1998). Particularly in our empirical context (which we introduce next), the Chinese government continued to rely on SOE agents to make key decisions on firms' innovation activities. The state lacked the ability to assess the substantive content (and thus the quality) of the patents other than counting the numbers of the produced patents.

innovation to enhance the innovativeness and, thus, the long-term value of firms and the country. Patents resulting from indigenous innovation in China have increased because of economic development (Hu & Jefferson, 2009; Huang, 2010). Moreover, it was only in 2006 that the state started to fully pursue this policy goal through major political campaigns originating from the central level and systematically build an incentive system to promote domestic innovation. Among the most important overarching policy guidelines for promoting indigenous innovation in China are the "China's National Medium- to Long-term Plan for the Development of Science and Technology (2006-2020)" by the State Council of China in 2006 and the follow-up "National Intellectual Property Strategy (2008)," which called for the enhancement of overall innovation capability and for the transformation of China into an innovative society by 2020 (Abrami et al., 2014). These policies were included in the 12th Five-Year Plan,[3] which stipulated that China would pursue an ambitious program of technological development that would enable the country to enter the ranks of innovative countries by 2020 and become a global scientific power by mid-century.[4] These policies also explicitly encourage indigenous inventions and patents filed with the State Intellectual Property Office (SIPO), China's equivalent agency to the United States Patent and Trademark Office (USPTO). To implement these overarching general policy guidelines, subsequent policies specified several channels to reach these goals, including the pro-indigenous innovation government procurement policy that we utilize below in our empirical analysis.

These policy guidelines and subsequent public policies reward the following innovation outcomes. First, the state designed comprehensive and actionable plans for faster accumulation of

[3] The Five-Year Plans, which set goals and paths for the country's development every five years, are the most important social and economic initiatives developed by the Communist Party of China.

[4] "China's National Medium- to Long-term Plan for the Development of Science and Technology (2006-2020)," issued by the State Council of China (2006). A Chinese version of this document is available at http://www.gov.cn/jrzg/2006-02/09/content_183787.htm (a summary in English is available at http://www.most.gov.cn/eng/pressroom/200507/t20050706_22978.htm).

patents. The aforementioned policy directives included specific clauses that mandated the overall national patenting targets, that is, achieving a set number of patents within a given length of time. For example, the state decreed that local firms must apply for two million patents by 2015.[5] The overall targets were then allocated to local governments, and many local governments accordingly adopted policies to provide direct monetary incentives to apply for patents.[6] For instance, Zhangjiagang City in Jiangsu Province increased its patent subsidy in June 2006 for an invention patent application from RMB 1,500 to RMB 3,000 and added a reward of RMB 10,000 if the application was eventually granted (e.g., Lei, Sun, & Wright, 2013). As documented in many media reports, the quantity of patent production became a dominant metric in the incentive system created by the Chinese state to promote indigenous innovation.[7]

In addition to the quantity outcome, the novelty of patents constitutes another important dimension. However, despite the importance of patent novelty to policymakers, minimal checks on the quality or novelty of patents have been implemented in pro-innovation public policies in China, and policy documents have failed to produce specific and actionable plans for quality checks, which is a stark contrast to the various metrics implemented to assess the quantities of patents (e.g., Liang, 2012).

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[5] "Patent fiction." *The Economist,* December 13, 2014.

[6] This governance approach of cascading quantitative targets to lower level governments has a long history and continues to prevail in the Chinese political system. The central government designates a quantified target for each province (e.g., a required minimum "floor" or a required maximum "ceiling"—depending on the issue in question—for certain metrics). Then, each provincial government decomposes its target for each next-level government in the province, which similarly cascades its share of the target to lower level governments. For example, Oi (1989: 58) documents that the state's procurement of grain in the 1950s followed such a cascading procedure, in which "the provincial party secretary divided the provincial target among the different prefectures." In another example, the central government attempted to achieve workplace safety goals by stipulating ceilings regarding annual workplace accident deaths to provincial governments, which then divided the number of allowed deaths among local governments (Fisman & Wang, 2017).

[7] For example, see "Chinese firms are filing lots of patents. How many represent good ideas?" *The Economist,* October 14, 2010, and "Patent fiction." *The Economist,* December 13, 2014.

In summary, the Chinese state adopted evaluation metrics characterized by heavy reliance on directly measurable outcomes of the quantity of patents and minimum specifications regarding the evaluation of patent novelty. This approach dominated the formulation and implementation of many follow-up policies. Therefore, the state's implementation of the pro-innovation policy constitutes an example of a principal (of SOEs) that adopts metrics that more heavily rely on quantifiable outcomes to evaluate the innovation performance of agents. Thus, the post-policy periods (2007 and afterwards) constitute a good indicator of the adoption of these metrics.

Finally, considerable regional variation in government quality exists in this context. At the root of governmental quality is the quality of external institutions that discipline governmental behavior. China generally lacks the institution of partisan competition in democracy to enhance governmental quality along the Weberian principles (e.g., Przeworski, Stokes, & Manin, 1999). However, substantial regional disparity remains in the extent to which local government officials are held accountable to the public interest and are constrained from straying off to pursue their private interests (e.g., Cai, Fang, & Xu, 2011; Cull & Xu, 2005; Xu, 2011). This variation occurs because China essentially adopted a model of regional decentralization in its reforms (Xu, 2011).

METHODS

Data and Sample

We collect data on all publicly listed firms from WIND, a comprehensive database that compiles all public information disclosed by listed firms in China. From the SIPO, we obtain invention patents filed by all listed firms in China from 2000 to 2012 *and eventually granted* by the SIPO.[8] Consistent with prior practice (Gans, Hsu, & Stern, 2008; Huang & Murray, 2009;

[8] The SIPO grants three types of patents: invention, utility model, and design patents. Compared with the other two categories, invention patents are the most substantive and rigorously examined patent, as they face the highest scrutiny and the strictest screening for quality and novelty in the approval process. The utility model and design patents

Huang, 2017), we regard the year of application as the time when a patent was produced. We focus on SOEs in the main analysis and offer a discussion of privately owned enterprises in the "Future Research" section.

We leverage the innovation procurement policy, which is a top-down policy that was formulated under the overarching policy guidelines discussed above, as the exogenous event in the natural experiment. This policy mandated that governments purchase given categories of products only from the firms that were deemed to have been active in developing Chinese indigenous innovation. The list of industrial categories of products included in the catalog is reported in Appendix A. In practice, the central government provides a general catalog of products to which the procurement policy applies, and each provincial government made minor variations to the catalog to suit its particular circumstances. A comparison of the product catalogs published by multiple provincial governments suggests that the specific product categories are highly similar across provinces. Note that the goal of this policy was *not* to secure the suppliers of government contracts, but to increase the financial incentives of firms to produce innovation in designated fields or industrial categories by at least temporarily increasing governmental demand for their products. The details and product categories were unknown to the public until the policy was announced in 2006. Hence, we take the year after the announcement of the innovation procurement policy, that is, 2007, as the beginning of the period in which the policy effect began. Our data begin in 2000 and end in 2012, a reasonably long time window that helps us maintain a relative balance of years before and after the policy.

generally cover more incremental inventions (with no substantive examination required) and product designs, respectively (e.g., Hu & Jefferson, 2009). Given the difference in the nature of patents, the examination procedure, and the amount of protection, we focus on invention patents for consistency, which follows the approach adopted in prior studies (e.g., Wang, Li, & Furman, 2017). Invention patents granted by the SIPO also correspond better to the invention patents granted by the USPTO (known as utility patents in the U.S.) used in prior studies. In doing so, we restrict our attention to more-novel patents in the entire pool of domestic patents. We offer further discussion of the implications of this approach in the Results section.

Finally, we obtain province-year-level information from the China Statistical Yearbooks and the index of marketization of Chinese provinces developed by the National Economic Research Institute of China (NERI) (published as Fan, Wang, & Zhu, 2011). The NERI indices were validated and used in prior studies (e.g., Li & Qian, 2013; Wang & Qian, 2011; Jia, 2014; Jia & Mayer, 2017; Huang et al., 2017).

Variables

Dependent variables. We focus on two dependent variables: *number of patents*, defined as the total number of patents generated by firms in a given year, and *proportion of novel patents*, defined as the proportion of novel patents among all the patents produced by the focal firm in the given year. We follow the method developed by Fleming, Mingo, and Chen (2007) and regard a patent as novel if it involves the first occurrence of a new combination of patent classes compared with all the patents that have ever been granted by the SIPO until the observation year.

Explanatory variables. Our first explanatory variable is *post policy*. To construct this variable, we follow Singh and Agarwal (2011) and first construct an indicator variable of policy treatment. We regard an SOE as treated if its SIC3 industry classification belongs to the industrial categories that produced one or more products designated in the government procurement catalogs. (We provide more detailed discussion of how we constructed the treatment and the control samples in the next section.) For a treated SOE, the indicator variable *post policy* is defined as one for the observation years that fall after 2006, the year of the policy issuance, i.e., equal to or later than 2007, and zero otherwise. For a non-treated SOE, *post policy* is always defined as zero.

To measure the degree of alignment between agents' private interests and firm value, we measure the *proportion of board share* as the percentage of firm shares owned by board members. The private incentives of board members shape how they monitor firm management and make important decisions for the firm (Hillman & Dalziel, 2003). In addition, the firm's key decisions must be communicated to or approved by the board. Many top managers have also sat on boards (on average, top managers account for more than 39% of board members). As a robustness check, we also examine an alternative variable, namely, the percentage of board members who held any firm share. The results (available upon request) are consistent. To measure the degree of firm monitoring, we draw on the established approach in the blockholder literature where larger blockholders tend to exert extra effort in monitoring management because they have further interests at stake (e.g., Kochar & David, 1996; Dharwadkar, Goranova, Brandes, & Khan, 2008). This finding follows that the higher the shares the state owns in an SOE, the greater the incentive the state has in monitoring the value of the SOE. Thus, we construct the *proportion of state share*, defined as the proportion of firm shares owned by the state. We regard an increased value for this variable to proxy for a higher degree of monitoring exercised by the state principal on SOEs.

To measure the quality of public governance, existing literature offered three common approaches. The earliest approach relied on crude proxies, such as state revenue and expenditures (Rubinson, 1977) and the occurrence of political assassinations and revolutions (Barro, 1991) which were proven inadequate (e.g., Evans and Rauch, 1995). Later, Evans and Rauch (1999) and Rauch and Evans (2000) surveyed experts to assess selected features of government, such as the presence of meritocratic recruitment and career ladder. The advantage was that these measures directly assessed certain aspects of public governance. However, the downside was that they did not comprehensively assess all aspects theorized by the Weberian principle. The measures generated by Evans and Rauch (1999) and Rauch and Evans (2000) covered a cross-sectional set of 35 countries in the 1990s, whereas subsequent research did not extend the data to cover other governments and time periods. To the best of our knowledge, a measure generated in this tradition is unavailable for regional governments in China.

The last approach, which is also the most popular and common one in the current literature, is to infer Weberian governance based on an array of outcomes produced when state actors carry out state functions efficiently without delays, corruption, or other distortions or when they fail to do so. Based on the Weberian theory of government quality, a high-quality government comes in a package in which multiple dimensions of government behavior are highly correlated. This finding means that a government that is increasingly accountable to public interest would also refrain from extracting from citizens and interfering in private businesses in multiple domains (La Porta et al., 1999; Acemoglu & Johnson, 2005). The most prominent of these features is minimal corruption, strong protection of private property rights, and modest extraction from citizens. At the country level, scholars (e.g., Knack and Keefer, 1995) and policy institutions (e.g., the World Bank) actively followed this approach to produce and constantly update an array of government quality measures. We also follow this tradition to examine, instead of cross-country variation, the quality of governments across different regions within one country, namely, China. We generate a composite index using the following four sub-indices published by the NERI, each of which proxies for one or more of the aforementioned outcomes of government quality.

The first sub-index was constructed by the NERI based on the percentage of nontax fees and charges on firms as a percentage of focal firms' sales in the province and focal year. These levies fall outside the formal tax obligations of firms. Hence, they effectively capture the extent to which governments infringe on private property, a strong proxy of a low-quality government (e.g., Acemoglu & Johnson, 2005). This sub-index was inversely constructed such that a high value indicates low nontax fees and charges levied by governments and, thus, not as much state expropriation. The second sub-index was constructed based on nontax fees and charges on rural residents as a percentage of their annual income. Fees and charges on rural residents have been one of the major sources of revenue for local governments in China. In addition, they constitute the dominant financial burden of Chinese peasants, which has become one of the central issues that exemplify the excessive fiscal predation by local governments (e.g., Yep, 2004; Fan, Wang, & Zhu, 2011). The third sub-index was constructed based on annual nationwide surveys that polled the firms to rank the importance of dealing with government officials in their business operations relative to other business tasks. Firm-level responses were aggregated to the level of the province. Reduced time needed to deal with government officials is considered to indicate efficient or high-quality government in China and other contexts (Fan et al., 2011). This standard question is adopted by surveys on government quality. For example, the World Bank Enterprise Survey also adopts the same approach of using managerial time spent on working through bureaucratic red tape to proxy for expropriation by government officials because bureaucratic red tape creates increased opportunities for state actors to seek private payments that infringe on firm private property across many emerging markets (Cull & Xu, 2005; Mako & Xu, 2006; Li et al., 2006; Tonoyan, Strohmeyer, Habib, & Perlitz, 2010; Spencer & Gomez, 2011). The fourth sub-index was constructed based on the excessive size of government employees (overstaffing), which increases the chance of government expropriation (Jia & Mayer, 2017).

We conduct principal component analysis based on these four sub-indices each year and use the first component as the variable *government quality* in the focal year. Across all years, the average Eigenvalue of the first component is 1.72, explaining 43% of the variance. Average factor loadings of the four sub-indices are 0.68 for nontax fees and charges on firms as a percentage of focal firms' sales, 0.31 for nontax fees and charges on rural residents as a percentage of their annual income, 0.67 for the importance of dealing with government officials in business operations, and 0.09 for the excessive size of government employees.

We establish two important points about this measure. First, we do not assert that each component alone proxies for how well governments serve as the principals of SOEs. Each component alone can be influenced by not only the quality of government, but also numerous less-relevant factors. The use of the common variance of the multiple components is important, which is determined by government quality and does not contain the idiosyncratic determinants of each component. Second, the fundamental theoretical root of this approach is that multiple dimensions of government behavior are highly correlated in the tradition of Weber (1968). That is, a high-quality government comes in a package: it effectively performs its role in advancing public interest (including managing SOEs) and, to a greater extent, refrains from infringing on the interest of private citizens. Therefore, although the sub-indices do not directly measure the management of SOEs, the variation captured by their common variance should proxy for the variation in how well governments perform their function as principals of SOEs.

Control variables. We control for the following variables at the firm level: *firm age* (years since the firm's founding), *firm size* (total assets), *ROA* (return on asset to proxy for firm performance), and *market to book ratio*. Given the importance of organizational slack in influencing firm innovation (e.g., Damanpour, 1991), we control for *unabsorbed slack*, which is the ratio of current assets to current liabilities and *potential slack*, which is the ratio of debt to equity with a high value denoting less potential slack. To proxy and control for the firm's innovative capability or capacity, we include the variable *cumulative number of patents*, which is the total number of patents that the firm has generated since the year of the firm's establishment until the year before observation year. To control for other important characteristics of boards and

CEOs, we include the following variables in our models: *government experience*, which denotes the proportion of board members with experience working in government positions; *independent director*, which denotes the proportion of independent directors on the board; *CEO and chairman duality*, which indicates the overlap of CEO and Chairman of the board; and *CEO Salary*, which is a proxy for the CEO's monetary incentives.

We also included the following province–year-level control variables. *Province GDP per capita* captures the GDP per capita of a provincial-level region in a particular year. *Province R&D expenditure* captures the R&D expenditures made by independent research institutions, institutes of higher learning or universities, and large- and medium-sized enterprises of a provincial-level region (in 10,000 Yuan). *Province market development* is a NERI index that particularly measures how well product markets are developed in each provincial-level region in each year. The NERI constructed this index based on two sub-indices: (1) percentage of products with market-regulated prices and (2) degree of local trade protection (Fan et al., 2011; Li et al., 2006). With the exception of *post policy*, all explanatory and control variables are lagged by one year. We include firm fixed effects in all models. Table 1 summarizes the variables and their pairwise correlations.

Insert Table 1 about here

Estimation Methods

We follow prior research in employing a difference-in-differences identification approach (e.g., Murray & Stern, 2007; Singh & Agrawal, 2011), wherein we examine the interaction between policy treatment and governance variables. As discussed previously, the treatment group includes SOEs belonging to the industrial categories that produced one or more products designated in the 2006 government procurement catalogs. We adopt propensity score matching[9] to construct a control group, namely, SOEs that did *not* belong to industrial categories whose products were designated in the procurement policy but were comparable to SOEs in the treatment group by matching the control group to the treatment group on key attributes including firm age, firm size, proportion of state share, cumulative number of patents, and year indicators. The difference in the numbers of patents produced by the treatment and control groups prior to the policy shock was not statistically significant, nor are the numbers of novel patents produced by them prior to the policy shock. This lends further support to the notion that the observable patenting behavior of the treatment and control firms is comparable. In the main models, we conduct difference-in-differences estimations for the full sample to compare the difference between the two groups of SOEs before and after the policy. In alternative models, we examine the differences among only SOEs in the treatment group before and after innovation policy. According to Singh and Agrawal (2011), this is a more stringent specification. This alternative model offers a direct test among the affected SOEs, which we consider comparable with one another in terms of the demand they face in developing patents and relevance of patenting to their businesses.

The first dependent variable, *number of patents*, is a highly right-skewed count variable that takes on non-negative integer values. Hence, we use a nonlinear regression approach to avoid heteroskedastic, non-normal residuals (Hausman, Hall, & Griliches, 1984). Specifically, we use conditional quasi-maximum likelihood (QML) estimates of the Poisson model with firm fixed effects (Hausman et al., 1984). The fixed-effects Poisson estimator produces consistent estimates of the parameters in an unobserved component multiplicative panel data model under very general conditions and provides consistent estimates of the conditional mean function even if the variances

[9] In the propensity score matching procedure, we use a caliper of 0.15, which is sufficiently tight to produce close matches for efficiency. As a relatively large pool of untreated subjects from which to select from for the matching procedure exists, a tight caliper is appropriate. Robustness checks using a caliper of 0.20 or 0.25 yield similar results.

are mis-specified (Wooldridge, 1997). Robustness checks using negative binomial regression models yield consistent results. We also incorporate robust standard errors in the fixed-effects Poisson models based on Wooldridge (1997), where we use the Huber–White sandwich estimator (Greene, 2004) in all models to account for possible heteroskedasticity and lack of normality in error terms. QML (i.e., robust) standard errors are consistent even if the underlying data-generating process is not Poisson.

The second dependent variable, *proportion of novel patents*, is computed as the number of novel patents divided by the total number of patents produced by firms in the given year which takes a value between 0 and 1. Thus, we use a double-censored Tobit model clustered by firm to account for possible correlations in errors for applying for novel patents within each firm. We also use robust standard errors to account for possible heteroscedasticity and lack of normality in the error terms (Greene, 2004). This approach follows prior studies and yields more consistent estimates of parameters than those of ordinary least squares (OLS) models (Long, 1997; McDonald & Moffitt, 1980; Tobin, 1958) because OLS models (inappropriately) treat the upper limit of the dependent variable (i.e., one) as actual values and not as the upper limit of the *proportion of novel patents*. We also include firm fixed effects throughout.

RESULTS

Table 2 reports the results of the preferred models for the difference-in-differences estimation on the full sample that include the treated and control groups in Models 2-1, 2-2, 2-5, and 2-6, as well as the more stringent models that analyze the treated group only in Models 2-3, 2-4, 2-7, and 2-8. As a point of comparison, we first examine the main effect of *post policy* along with the control variables, but without the interaction terms. The results show that, overall, the *number of patents* (Models 2-1 and 2-3) and *proportion of novel patents* (Models 2-5 and 2-7) increased after the implementation of policy. However, these changes should not be uniform according to our hypotheses. Thus, we continue to examine their differential effects for various types of firms or regions—i.e., interaction effects.

Table 2 also reports the results from estimating the interaction effect of *post policy* and *proportion of board share*, our measure of the incentive alignment of SOE agents. In predicting the outcome of the *number of patents*, the estimated coefficient of this interaction term for the full sample in Model 2-2 is negative and significant ($p < 0.05$), which is consistent with the prediction of H1a. For firms whose *proportion of board share* is at a moderate level (mean value), their patent production increased by 54.44% after the policy compared with before the policy. By contrast, for firms with high *proportion of board share* (one standard deviation above the mean), their patent production increased by a relatively smaller magnitude of 37.05% after the policy compared with before the policy. Therefore, firms with a moderate level of *proportion of board share* experienced a larger post-policy increase in patent production compared with the firms with a high level of *proportion of board share*, by a magnitude of close to 18 percentage points. As a robustness check, the estimation on the treatment group subsample in Model 2-4 yields highly similar results, wherein the interaction effect between *post policy* and *proportion of board share* is negative and statistically significant ($p < 0.01$) with a similar magnitude. These results suggest that although the policy produced a high quantity of patents generated by SOEs on average, this effect is not the same across all SOEs. The magnitude of this post-policy increase is notably small for SOEs, in which the private interests of their agents are aligned with firm value. Therefore, the results support H1a.

We now turn to Models 2-6 (full sample) and 2-8 (treatment group only), which examine the *proportion of novel patents* produced by SOEs. In both models, the estimated coefficient of the interaction between *post policy* and *proportion of board share* is positive and significant ($p < 0.01$), which supports a positive interaction effect, as predicted in H1b. Note that the policy increased the average proportion of novel patents overall, as the coefficient of *post policy* is positive and significant in models without interaction terms in Models 2-5 and 2-7 (recall that our hypothesis does not focus on this overall effect, but on the differential effects based on firm types). Given the overall positive effect of *post policy* on the proportion of novel patents, the positive interaction term between *post policy* and *proportion of board share* suggests that this increase tends to be large for firms with high *proportion of board share.* For example, in the full sample results in Model 2-6, firms whose *proportion of board share* is at a moderate level (mean value) after the policy increased the *proportion of novel patents* by a magnitude of 11.52% compared with the pre-policy level, whereas firms whose *proportion of board share* is at a high level (one standard deviation above the mean) increased the *proportion of novel patents* by a much larger magnitude of 30.40% compared with that of the pre-policy level. In other words, the magnitude of post-policy increase in the *proportion of novel patents* is almost 19 percentage points higher for firms with better incentive alignment than for those with moderate incentive alignment. The results lend strong support to H1b.

Insert Table 2 about here

Table 3 reports the results of estimating the interaction effects between *post policy* and *proportion of state share*, which is a proxy for monitoring. This interaction effect is not statistically significant in predicting the *number of patents* (Models 3-2 and 3-4), which suggests that the overall increase in the quantity of patents after the policy does not appear to be affected by the *proportion of state share* in the SOEs. Thus, the results do not support H2a.

However, Models 3-6 and 3-8 show that the interaction between *post policy* and *proportion of state share* is a positive and significant ($p < 0.01$) predictor of the *proportion of novel patents* produced. Based on the full sample estimates reported in Model 3-6, SOEs with a moderate level of *proportion of state share* (mean value) increased the *proportion of novel patents* after the policy among all of its patents by a magnitude of 9.89% compared with the pre-policy level. SOEs with a high level of *proportion of state share* (one standard deviation above the mean) increased the *proportion of novel patents* among all its patents by a magnitude of 15.69%. In other words, the magnitude of the post-policy increase in the *proportion of novel patents* is larger by close to 6 percentage points or 59 percent points greater for SOEs with a higher level of state shares than that for SOEs with a moderate level of state shares. These results support H2b.

Thus far, the results suggest that SOEs whose board members' private financial incentives were further aligned with firm value through increased shareholding and produced a small post-policy increase in the quantity of general patents. These firms, together with the firms monitored to a great extent by the state through an enlarged state share, also produced a large post-policy increase in the proportion of novel patents among all patents. This evidence is consistent with our theory regarding the effect of incentive alignment on innovation.

Insert Table 3 about here

Table 4 reports the results of the interaction effects of government quality and policy treatment indicator. In predicting the quantity of patents, we find that the coefficient of the interaction between *post policy* and *government quality* is positive for the full sample in Model 4-2 ($p < 0.10$) and for the treated sample in Model 4-4 ($p < 0.05$), which does not support H3a.

Models 4-6 and 4-8 examine the interaction effects on the *proportion of novel patents*. In Model 4-6, the estimated interaction effect of *post policy* and *government quality* in the preferred full sample model is positive, as predicted by H2b, and statistically significant ($p < 0.01$). After the implementation of the policy, SOEs in provinces with moderate *government quality* (at the mean value) increased the *proportion of novel patents* by about 10.33% compared with that of the pre-policy level. SOEs in provinces with high *government quality* (at one standard deviation above the mean) increased the *proportion of novel patents* by about 11.14% compared with that of the pre-policy level. Although the magnitude of the differential is close to one percentage point which is relatively small, it should be interpreted from the perspective of the average *proportion of novel patents,* which is only 2.8%. These results provide support for H3b. For the subsample of the treatment group in the SOE sample in Model 2-8, the interaction term is not statistically significant from zero. Overall, the results based on the main model suggest that the local government's quality helped to further boost SOEs' tendency to produce a large proportion of novel patents relative to general patents after policy implementation.

Thus far, the results suggest that on average, the number of patents produced by the firms increased after the policy. However, this increase was smaller in magnitude for firms whose board held more shares, hence corroborating H1a. On average, the proportion of novel patents to all patents produced by the focal firm also increased after the policy. However, this increase was larger for firms under better governance such as those with higher *proportion of board share* and higher *proportion of state share* and located in provinces with higher-quality governments, which support H1b, H2b, and H3b. H2a and H3a are not supported, on which we offer more discussion later.

Insert Table 4 about here

To test the three-way interaction effects predicted by H4a to H4d, we adopt two approaches, namely, (1) conducting an analysis of two-way interactions in subsamples divided based on the third moderator, which offers the advantage of allowing the effects of other explanatory variables to also vary based on the third variable and (2) including three-way interaction terms and all constitutive two-way interaction terms in a single model.

Table 5 reports the results of the interaction effects of *proportion of board share*, *post policy*, and *government quality*. First, we compare the coefficients of the interaction terms, as demonstrated by the subsample analyses in Models 5-1 and 5-2, respectively. Next, we examine the three-way interaction term in Model 5-3. We find that the *number of patents* does not appear affected at conventional significance levels. Thus, we do not find support for H4a.

Regarding the proportion of novel patents, the interaction between *post policy* and *proportion of board share* has a negative and statistically significant ($p < 0.01$) effect on SOEs located in provinces with low *government quality* (Model 5-4). However, this interaction effect is positive and significant ($p < 0.01$) for SOEs located in provinces with high *government quality* (Model 5-5). These results suggest that the basic pattern in provinces with high-quality governments (Model 5-4) is similar to that of the overall effect found in the full sample (Model 2-6) but with a much larger magnitude. However, the pattern appeared to be very different in provinces of *low-quality* governments (Model 5-4), in which the interaction between post policy and board share reduced the proportion of novel patents. The contrast of the two contexts produced is a positive and statistically significant ($p < 0.01$) three-way interaction effect in a Mode 5-6. Overall, we find that the positive effect of board share on post-policy production of novel innovation is mainly driven by firms located in provinces with high-quality governments, which lends support to H4b.[10]

Insert Table 5 about here

[10] Nonetheless, the rich findings revealed one limitation. Our theory based on Holmstrom (1979) explains why, in a good institutional environment that has higher-quality governments, more-diligent agents (as a result of better corporate governance tools) are more likely to behave in ways that are consistent with promoting firm value. However, we do not have a theory about what happened in a bad institutional environment—in which corporate governance appeared to function in very different ways, as the empirical findings show. Although our theory hinges on explaining why firms in good institutional environments drive the results related to corporate governance and thus received support by the findings, we consider it a valuable quest to theorize particularly about what effect corporate governance produces (or a lack thereof) in a bad institutional environment.

Table 6 reports the results of the interaction effects of *proportion of state share*, *post policy*, and *government quality* on the quantity of patents. The two-way interaction between *post policy* and *proportion of state share* in predicting the quantity of patents is not statistically significant in either subsamples divided based on the median value of *government quality* (Models 6-1 and 6-2). However, the three-way interaction between *post policy*, *proportion of state share*, and *government quality* in Model 6-3 is a negative and statistically significant ($p < 0.01$) predictor of the *number of patents,* which is supports H4c, i.e., the negative effect of the interaction between *post policy* and *proportion of state share* on the *number of patents* should be more pronounced with greater *government quality*.

In predicting the proportion of novel patents, the two-way interaction between *post policy* and *proportion of state share* remains positive and statistically significant in both subsamples of provinces with low (Model 6-4) and high (Model 6-5) values of *government quality*. However, the difference of this interaction effect between the two subsamples is miniscule and not statistically significant at conventional levels. Model 6-6 shows that the three-way interaction term is not a statistically significant predictor of the *proportion of novel patents*. Hence, H4d is not supported.

Insert Table 6 about here

To summarize, all the hypotheses on the novelty of patents (Hypotheses 1b, 2b, 3b, and 4b) received empirical support. Regarding the hypotheses on the overall quantity of patents, Hypotheses 1a and 4c were supported but Hypotheses 2a, 3a, 4a, and 4d were not. Next, we offer a few thoughts on why the key estimates predicting the quantity of patents generally failed to be distinguishable from zero at conventional significance levels and how we can place the interpretations of our results in perspective.

We consider that our conservative approach of focusing only on invention patents that were eventually approved is much relevant to this outcome. Owing to this approach, our data include only the high-end invention patents in the entire spectrum of innovation. If in response to the national campaign, certain SOEs gamed the system by cranking out incremental technologies that did not meet the high patentability bar of invention patents (i.e., judged to have sufficient usefulness, novelty, and non-obviousness; Wang et al., 2017); thus, they were filed as one of the other two low-quality categories of patents (see Footnote 8); our data, which do not include the other two categories of patents for low-quality technologies, will underestimate the post-policy frenzy of certain firms in terms of increasing the volume of patents at the expense of novelty.

This conservative approach nonetheless helps further strengthen the interpretations of our results on patent novelty. Our findings show that even among the granted invention patents, which already passed the SIPO's more-rigorous examinations for novelty and were more difficult to develop than the other two categories of patents, we continue to observe that the most cutting-edge patents declined in proportion after the policy among the SOEs that are under weak corporate or public governance. This result suggests that corporate and public governance exerts a very strong influence in shaping the novelty of firm innovation, even for SOEs that were already developing invention patents.

Alternative Explanations

Did the state simply seek to quickly accumulate incremental patents? A potential conjecture is that quickly developing less novel patents may simply be in the best interests of the Chinese state. Thus, SOEs may simply have followed the state's instructions. However, this speculation is not consistent with the substantial empirical evidence that the state clearly and explicitly specified a strong desire to promote innovation and strong innovative capabilities in various policy documents. To the best of our knowledge, the Chinese state has never even hinted that patent quantity is more important than patent quality or novelty or that the latter can or should be sacrificed in pursuit of the former. Instead, the Chinese state has always unambiguously advocated the ambition of becoming a nation with the strongest innovative capabilities. Thus, the first conjecture seems consistent with the content of policy documents and vast array of in-context anecdotal evidence.

Nonetheless, we acknowledge that we cannot entirely rule out this alternative explanation. However, we distinguished between this conjecture and our theory based on the results of the variation in innovation outcomes, which depend on corporate and public governance. That is, focusing on the interaction effect of the post-policy indicator and measures of agency incentives helps address this concern. The alternative explanation cannot account for the interaction effects on which this study focuses. If the state indeed intentionally placed greater emphasis on the quantity of general patents more than their novelty, then this mandate should affect all SOEs across the board. However, our findings do not support this situation. Results regarding the interaction effects are more consistent with the agency-based explanation than the alternative explanation.

Can government contracts nullify firms' need to become truly innovative? The second challenge to the agency-based explanation is that even if agents' interests were fully aligned with firm interests (i.e., in the absence of agency risk), agents are not required to care about achieving a balance between less-novel and novel patents to improve their firm's innovativeness and competitiveness which contribute to firm value in market competition, provided that firms can be entirely shielded from market competition. This insulation from market competition may be achieved by obtaining all business from government contracts through this public policy, which, after all, is the "carrot" used by the state in this very policy instrument.

However, this explanation does not explain the main findings, i.e., that innovation behavior differs for SOEs with varying degrees of agency risk. Second, the need to compete in the market is not eliminated for most firms in our sample. For products included in the government procurement catalogs, significant growth opportunities exist owing to the large and growing market demand beyond government contracts. These are not simply any types of products. Many of these products belong to core manufacturing industrial categories for which large domestic and international markets are available. In addition, a notable proportion of them are technology-intensive products in fast-growing markets (see Online Appendix A). Furthermore, government procurement contracts issued owing to the pro-innovation policies is not guaranteed and would continue in the long term. The state clarified that its intention was not to secure suppliers for these contracts, but to use these contracts to induce notable innovation. Thus, several SOEs would continue to expect to compete for market demand even with government contracts. Therefore, the true innovative capabilities and competitiveness of firms still mattered, thereby weakening the plausibility of this alternative explanation.

DISCUSSION AND CONCLUSION

Innovation research often distinguishes true innovation from observable outcomes such as patents (Van de Ven, 1986; Gupta, Tesluk, & Taylor, 2007; Huang & Murray, 2009). The two notions are not fully aligned despite having high correlations. This paper examines how agency risk can contribute to one type of misalignment, that agents who are affected by greater moral hazard—shaped by corporate and public governance—pursue the observable quantity of innovation at the expense of the novelty.

We find that after the state issued the major pro-innovation policy in 2006 in China, Chinese SOEs responded differently depending on their corporate governance and the public governance of the governments that control them. SOEs whose board members held fewer shares (thus having less incentive alignment) and those with smaller proportions of state share (thus creating weaker monitoring by the state principal), and SOEs located in provinces with lower-quality public governance produced a smaller post-policy increase in the proportion of novel patents. SOEs whose board members held more shares also produced larger post-policy increase in the quantity of patents. However, the distinction of firms created by their state shares and quality of their local governments did not appear to affect the post-policy increase in the quantity of patents, for which we offered certain explanations based on our criteria of selecting the sample.

Moreover, the finding that board shares produced a large post-policy increase in the proportion of novel patents appeared to be mainly driven by SOEs located in provinces with high-quality governments but not by the SOEs located in provinces with low quality governments. This scenario is consistent with the theory that good political governance of the state principal enhances the effect of good corporate governance of SOE agents.

Theoretical Contributions

First, it is challenging for firms to manage innovation because of asymmetric information and greater uncertainty in measurement, so agency risk is rife. Prior research on agency risk in innovation mostly focused on how agents shirk and thus underinvest in innovation (e.g., Cohen & Levin, 1989; Zenger, 1994). This study demonstrates a different form of agency risk that affected the deployment of resources instead of reducing investment in innovation. Here, affected agents prioritize producing a larger quantity of innovation at the expense of quality. This insight provides a plausible mechanism for the findings in prior research that under higher agency risk, inputs into innovation less effectively contribute to firm value (e.g., He and Wang, 2009; Zhou et al., 2017).

Moreover, our distinction between the quantity and novelty of innovation expand the predominant focus on agents' underinvestment in innovation across the board (e.g., Baysinger et al., 1991; Kochhar & David, 1996; Lee & O'Neill, 2003; David et al., 2008). Our distinction of different innovation outcomes—the production of general or novel patents, is important for the following reasons. First, it is a critical feature that directly shapes how firm innovation eventually affects firm value (e.g., Mitchell, 1989, Henderson & Clark, 1990, Cockburn, 2004). Second, it contributes to the conceptual notion that agency risk affects how agents deploy innovation activities (He and Wang, 2009) by providing a theoretical mechanism. Third, this paper provides the first systematic examination of the distinction between the quantity and novelty of innovation in China, whereas previous discussion of this important issue was based on anecdotal evidence.

Second, this study also contributes to the theory of corporate governance. While corporate governance literature traditionally focuses on regulating the behavior of agents, recent research also recognizes the importance of governance of principals. For example, the national traditions in terms of the prevailing ownership types, national value, and governance logics influence how much principals hold agents accountable (e.g., Crossland and Hambrick, 2007; Crossland & Chen, 2013; Desender et al., 2016). Consistent with this direction, we show that, as part of a high-quality government, public officials effectively fulfill their role as principals of SOEs to reduce agents' moral hazard in the SOEs, which directly and further utilizes corporate governance tools. This study contributes to the frontier research that aims to understand why the effectiveness of the same corporate governance mechanisms appears to vary across the institutional environment because public governance is a core component of the institutional context (e.g., Aguilera et al., 2015).

Third, we contribute to the research on state capitalism by addressing the following tension. Several researchers argued that states are long-term oriented and use SOEs to achieve their goals, such as building innovative capabilities (Munari et al., 2010). Thus, these scholars have predicted that state ownership increases innovation in SOEs (Choi et al., 2011). However, these scholars suggest that state-controlled firms lack the abilities to appreciate innovation and show less innovation than privately owned firms (e.g., Hart et al., 1997; Shleifer, 1998). Zhou et al. (2017) provides a summary of this debate. We reconcile this tension by providing the following insights: despite promotion by the state, SOEs that suffer from great agency risk continue to lack an inherent interest in increasing firm value through engagement with innovation. However, it does not necessarily manifest as less innovation, but rather as a lopsided focus on the quantity of innovative outcomes at the expense of novelty. Therefore, the ability of the state as principal to increase SOEs' innovativeness is more intricate than suggested by prior research.

Managerial and Policy Implications

These findings also generate important managerial and policy implications. Producing a large quantity of patents in itself may not be detrimental to firm innovativeness and value. However, if the proportion of novel patents produced is also lower, then firm-level problems can arise for the following reason. Although scholars and practitioners believe that firms must achieve a balanced mix of incremental and novel innovation, most Chinese SOEs were unlikely to have previously already been in the position of overproducing novel patents prior to the policy change. Thus, scaling back novel patents or developing them at disproportionately slower rates than incremental patents is unlikely to be the optimal method of achieving the top level of firm innovativeness and value. Our study suggests that corporate and public governance tools appear to have reduced the extent of the asymmetric effect on the quantity and novelty of patents produced by the SOEs. Therefore, we conclude that replicating the market for innovation may be difficult for the state because of two challenges: (1) the divergent interests of SOE agents, which can be modified by multiple governance mechanisms, and (2) the inability of the state to design precise evaluation metrics that induce the types of managerial actions that contribute to ultimate firm value.

Another implication for the governance and innovation literature is that improved corporate governance, high-quality public governance, and their interaction effect can improve the proportion of novel patents in firms without a proportionate increase in incremental patents. To the extent that an increase in novel patents tends to correspond with a rise in the number of incremental patents, our finding provides a more nuanced view to refine this understanding.

Future Research

We primarily focused on SOEs in this paper since public governance directly affects how effective state officials perform the state's role as the principals of SOEs. We consider studying this type of moral hazard in the innovation of privately owned enterprises an interesting and fruitful venue for future research. First, the general theory of the effect of corporate governance on firm innovation should, in principle, be applicable to privately owned enterprises given that incentive alignment and monitoring are also general theoretical tools, which address agency risk in privately owned firms. Second, the governance of the principals of privately owned enterprises, even though it may not be public governance, such as those determined by different types of ownership (e.g., Desender et al., 2016), should also matter to firm innovation outcomes.

Although objective evaluation metrics in innovation does not always rely on firms' financial results, the notion of adopting metrics shares certain similarities with financial control with which managers assess the business primarily based on financial performance data. Research showed that tight financial control led to low-risk, short-term orientation, which in turn decreased the overall R&D innovation of firms (Hoskisson and Hitt, 1988). Future research can investigate whether financial control would also shape the composition of innovation above and beyond the overall amount of R&D, thereby connecting innovation research to the literature on corporate control and multidivisional firms.

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Figure 1. Theoretical Framework

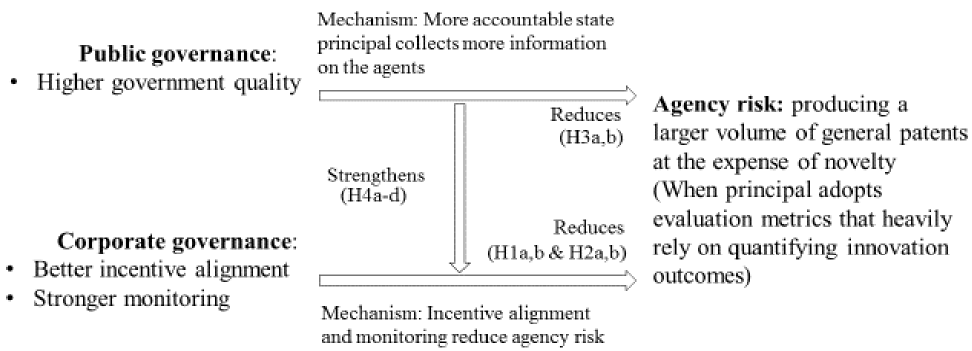

Table 1. Summary Statistics and Pairwise Correlations

	Mean	S. D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1 .Number of patents	2.83	23.05																			
2. Proportion of novel patents	0.028	0.12	0.07																		
3. Post policy	0.25	0.44	0.07	0.07																	
4. Proportion of board share	0.18	1.60	−0.00	−0.01	0.07																
5. Proportion of state share	0.11	0.20	0.10	0.02	−0.15	−0.04															
6. Government quality	0.41	1.02	0.00	0.03	0.01	0.01	0.05														
7. Firm age	10.33	4.91	−0.01	−0.01	0.30	−0.04	−0.09	0.09													
8. Firm size	21.49	1.19	0.26	0.09	0.14	−0.04	0.03	−0.00	0.17												
9. ROA	0.03	0.08	0.03	0.04	0.00	0.09	−0.02	0.01	−0.13	0.14											
10. Market to book ratio	1.84	1.45	−0.04	−0.03	−0.00	0.08	−0.02	−0.02	−0.12	−0.39	0.17										
11. Unabsorbed slack	1.67	2.04	−0.02	−0.01	0.01	0.21	−0.06	−0.02	−0.12	−0.14	0.16	0.22									
12. Potential slack	2.11	23.16	−0.00	−0.01	−0.01	−0.01	0.00	−0.00	0.03	−0.02	−0.03	−0.01	−0.03								
13. Cumulative number of patents	10.41	96.84	0.89	0.04	0.07	−0.00	0.07	−0.01	0.02	0.24	0.02	−0.03	−0.02	−0.00							
14. Government experience	0.32	0.29	0.07	0.06	0.32	0.03	−0.12	0.03	0.38	0.27	0.00	−0.18	−0.04	0.01	0.08						
15. Independent director	0.28	0.14	0.06	0.05	0.31	0.04	−0.12	0.05	0.42	0.24	−0.04	−0.28	−0.06	0.00	0.04	0.55					
16.CEO and Chairman duality	0.30	0.46	0.00	−0.01	−0.04	0.04	0.04	0.00	−0.01	−0.02	−0.01	0.02	−0.02	−0.01	−0.00	−0.05	−0.05				
17.CEO salary	334113	469326	0.08	0.03	0.20	0.07	−0.12	−0.01	0.24	0.41	0.14	−0.01	0.01	−0.01	0.09	0.23	0.21	0.01			
18. Province GDP per capita	27373	20106	0.08	0.02	0.27	0.07	−0.07	0.07	0.36	0.27	0.04	−0.00	0.02	−0.01	0.10	0.27	0.29	−0.05	0.38		
19. Province R&D expenditure	2352962	4770786	0.03	0.03	0.17	0.06	−0.07	0.21	0.20	0.12	0.02	−0.04	0.02	−0.01	0.04	0.15	0.16	−0.00	0.21	0.41	
20. Province market development	7.79	1.51	0.01	0.03	0.13	0.02	0.01	0.35	0.26	0.12	−0.01	−0.13	−0.05	0.01	0.01	0.17	0.26	−0.07	0.13	0.23	0.15

Table 2. Effects of Post-policy and Board Share on Quantity and Novelty of Patents

Model	2-1	2-2	2-3	2-4	2-5	2-6	2-7	2-8
DV	FE Poisson Number of patents	FE Poisson Number of patents	FE Poisson Number of patents	FE Poisson Number of patents	Tobit (firm FE) Proportion of novel patents	Tobit (firm FE) Proportion of novel patents	Tobit (firm FE) Proportion of Novel Patents	Tobit (firm FE) Proportion of Novel Patents
Sample	**All samples (preferred model)**	**All samples (preferred model)**	**Subsample of treatment group of SOE only (no control group)**	**Subsample of treatment group of SOE only (no control group)**	**All samples (preferred model)**	**All samples (preferred model)**	**Subsample of treatment group of SOE only (no control group)**	**Subsample of treatment group of SOE only (no control group)**
Proportion of board		−0.100*		−0.083**		0.118**		1.107**
share × Post policy		(0.050)		(0.026)		(0.000)		(0.000)
Proportion of board	0.031	0.105	0.015	0.083^{+}	−0.030**	−0.139**	−0.028**	−1.130**
share	(0.057)	(0.065)	(0.052)	(0.042)	(0.000)	(0.000)	(0.000)	(0.000)
Post policy	0.441**	0.446**	0.631**	0.635**	0.096**	0.094**	0.168**	0.156**
	(0.124)	(0.124)	(0.104)	(0.104)	(0.003)	(0.003)	(0.003)	(0.003)
Firm age	0.115**	0.114**	0.061	0.060	0.015**	0.015**	−0.006**	−0.007**
	(0.041)	(0.041)	(0.051)	(0.051)	(0.000)	(0.000)	(0.000)	(0.000)
Firm size	0.601**	0.602**	0.788**	0.789**	0.029**	0.030**	0.043**	0.047**
	(0.172)	(0.172)	(0.202)	(0.203)	(0.000)	(0.000)	(0.000)	(0.000)
State share	0.444**	0.445**	−0.030	−0.030	0.231**	0.231**	0.176**	0.175**
	(0.170)	(0.170)	(0.258)	(0.258)	(0.002)	(0.002)	(0.002)	(0.002)
ROA	−0.398	−0.368	−0.398	−0.387	1.721**	1.722**	1.956**	1.950**
	(0.705)	(0.699)	(0.713)	(0.715)	(0.015)	(0.015)	(0.018)	(0.017)
Market to book ratio	0.014	0.014	0.012	0.013	−0.029**	−0.029**	−0.046**	−0.045**
	(0.034)	(0.034)	(0.039)	(0.039)	(0.001)	(0.001)	(0.001)	(0.001)
Unabsorbed slack	0.009	0.012	−0.030	−0.025	0.007**	0.007**	0.001	0.001
	(0.042)	(0.042)	(0.045)	(0.045)	(0.001)	(0.001)	(0.001)	(0.001)
Potential slack	−0.019	−0.019	−0.060	−0.060	−0.003**	−0.003**	−0.000	−0.000
	(0.025)	(0.024)	(0.042)	(0.042)	(0.000)	(0.000)	(0.000)	(0.000)
Cumulative number of	0.000	0.000	−0.001**	−0.001**	−0.000**	−0.000**	−0.000**	−0.000**
patents	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Government experience	−0.013	−0.015	0.492**	0.491**	0.158**	0.159**	0.212**	0.213**
	(0.210)	(0.210)	(0.164)	(0.164)	(0.003)	(0.003)	(0.004)	(0.004)
Independent director	1.337*	1.340*	0.975	0.979	0.447**	0.445**	0.200**	0.188**
	(0.599)	(0.596)	(0.624)	(0.622)	(0.005)	(0.005)	(0.006)	(0.006)
CEO and chairman	0.066	0.065	−0.061	−0.062	−0.078**	−0.078**	−0.044**	−0.044**
duality	(0.136)	(0.137)	(0.154)	(0.155)	(0.001)	(0.001)	(0.002)	(0.002)
CEO salary	0.000	0.000	0.000	0.000	0.000**	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province GDP per capita	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province R&D	0.000^{+}	0.000^{+}	0.000*	0.000*	0.000**	0.000**	0.000**	0.000**
expenditure	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province market	0.102	0.102	0.157^{+}	0.157^{+}	0.011**	0.011**	−0.023**	−0.022**
development	(0.094)	(0.094)	(0.094)	(0.094)	(0.000)	(0.000)	(0.000)	(0.000)
Firm fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	3,676	3,676	2,539	2,539	6,622	6,622	3,324	3,324
Log pseudolikelihood	−7499	−7493	−5727	−5723	−1118	−1117	−808	−807

Robust standard errors are in parentheses. All tests are two-tailed and include constant. Models 2-1, 2-3, 2-5, and 2-7 are identical to Models 3-1, 3-3, 3-5, and 3-7, respectively. ** $p < 0.01$, * $p < 0.05$, $^{+}p < 0.1$

Table 3. Effects of Post-policy and State Share on Quantity and Novelty of Patents

Model	3-1	3-2	3-3	3-4	3-5	3-6	3-7	3-8
DV	FE Poisson Number of patents	FE Poisson Number of patents	FE Poisson Number of patents	FE Poisson Number of patents	Tobit (firm FE) Proportion of novel patents	Tobit (firm FE) Proportion of novel patents	Tobit (firm FE) Proportion of Novel Patents	Tobit (firm FE) Proportion of Novel Patents
Sample	**All samples (preferred model)**	**All samples (preferred model)**	**Subsample of treatment group of SOE only (no control group)**	**Subsample of treatment group of SOE only (no control group)**	**All samples (preferred model)**	**All samples (preferred model)**	**Subsample of treatment group of SOE only (no control group)**	**Subsample of treatment group of SOE only (no control group)**
Proportion of state share		−0.034		0.116		0.291**		0.295**
× Post policy		(0.327)		(0.325)		(0.009)		(0.012)
Proportion of state share	0.444**	0.462	−0.030	−0.109	0.231**	0.143**	0.176**	0.051**
	(0.170)	(0.289)	(0.258)	(0.419)	(0.002)	(0.006)	(0.002)	(0.009)
Post policy	0.441**	0.447**	0.631**	0.609**	0.096**	0.066**	0.168**	0.125**
	(0.124)	(0.127)	(0.104)	(0.118)	(0.003)	(0.003)	(0.003)	(0.003)
Proportion of board share	0.031	0.030	0.015	0.016	−0.030**	−0.029**	−0.028**	−0.028**
	(0.057)	(0.057)	(0.052)	(0.052)	(0.000)	(0.000)	(0.000)	(0.000)
Firm age	0.115**	0.114**	0.061	0.064	0.015**	0.016**	−0.006**	−0.003**
	(0.041)	(0.041)	(0.051)	(0.050)	(0.000)	(0.000)	(0.000)	(0.000)
Firm size	0.601**	0.602**	0.788**	0.784**	0.029**	0.023**	0.043**	0.040**
	(0.172)	(0.176)	(0.202)	(0.202)	(0.000)	(0.000)	(0.000)	(0.000)
ROA	−0.398	−0.402	−0.398	−0.395	1.721**	1.725**	1.956**	1.942**
	(0.705)	(0.700)	(0.713)	(0.721)	(0.015)	(0.015)	(0.018)	(0.018)
Market to book ratio	0.014	0.014	0.012	0.011	−0.029**	−0.028**	−0.046**	−0.044**
	(0.034)	(0.034)	(0.039)	(0.040)	(0.001)	(0.001)	(0.001)	(0.001)
Unabsorbed slack	0.009	0.009	−0.030	−0.029	0.007**	0.007**	0.001	−0.000
	(0.042)	(0.042)	(0.045)	(0.045)	(0.001)	(0.001)	(0.001)	(0.001)
Potential slack	−0.019	−0.019	−0.060	−0.060	−0.003**	−0.003**	−0.000	0.000
	(0.025)	(0.025)	(0.042)	(0.043)	(0.000)	(0.000)	(0.000)	(0.000)
Cumulative number of	0.000	0.000	−0.001**	−0.002**	−0.000**	−0.000**	−0.000**	−0.000**
patents	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Government experience	−0.013	−0.014	0.492**	0.496**	0.158**	0.154**	0.212**	0.204**
	(0.210)	(0.210)	(0.164)	(0.162)	(0.003)	(0.003)	(0.004)	(0.004)
Independent director	1.337*	1.342*	0.975	0.950	0.447**	0.435**	0.200**	0.181**
	(0.599)	(0.621)	(0.624)	(0.596)	(0.005)	(0.005)	(0.006)	(0.006)
CEO and chairman	0.066	0.063	−0.061	−0.054	−0.078**	−0.081**	−0.044**	−0.047**
duality	(0.136)	(0.140)	(0.154)	(0.163)	(0.001)	(0.001)	(0.002)	(0.002)
CEO salary	0.000	0.000	0.000	0.000	0.000**	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province GDP per capita	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province R&D	0.000+	0.000+	0.000*	0.000*	0.000**	0.000**	0.000**	0.000**
expenditure	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province market	0.102	0.101	0.157+	0.157+	0.011**	0.010**	−0.023**	−0.025**
development	(0.094)	(0.093)	(0.094)	(0.094)	(0.000)	(0.000)	(0.000)	(0.000)
Firm fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	3,676	3,676	2,539	2,539	6,622	6,622	3,324	3,324
Log pseudolikelihood	−7499	−7499	−5727	−5726	−1118	−1116	−808	−807

Robust standard errors are in parentheses. All tests are two-tailed and include constant. Models 2-1, 2-3, 2-5, and 2-7 are identical to Models 3-1, 3-3, 3-5, and 3-7, respectively. **p < 0.01, *p < 0.05, +p < 0.1

Table 4. Effects of Post-policy and Government Quality on Quantity and Novelty of Patents

Model	4-1	4-2	4-3	4-4	4-5	4-6	4-7	4-8
DV	FE Poisson Number of patents	FE Poisson Number of patents	FE Poisson Number of patents	FE Poisson Number of patents	Tobit (firm FE) Proportion of novel patents	Tobit (firm FE) Proportion of novel patents	Tobit (firm FE) Proportion of novel patents	Tobit (firm FE) Proportion of novel patents
Sample	**All samples (preferred model)**	**All samples (preferred model)**	**Subsample of treatment group of SOE only (no control group)**	**Subsample of treatment group of SOE only (no control group)**	**All samples (preferred model)**	**All samples (preferred model)**	**Subsample of treatment group of SOE only (no control group)**	**Subsample of treatment group of SOE only (no control group)**
Government quality × Post-policy		0.222^{+}		0.251*		0.008**		−0.002
		(0.115)		(0.122)		(0.003)		(0.003)
Government quality	0.014	−0.060	−0.041	−0.165^{+}	0.049**	0.047**	0.049**	0.050**
	(0.064)	(0.061)	(0.090)	(0.097)	(0.001)	(0.002)	(0.001)	(0.002)
Post-policy	0.448**	0.328*	0.613**	0.451**	0.104**	0.100**	0.183**	0.185**
	(0.125)	(0.146)	(0.106)	(0.126)	(0.002)	(0.003)	(0.003)	(0.004)
Proportion of state share	0.441*	0.446**	−0.025	0.008	0.225**	0.224**	0.165**	0.165**
	(0.175)	(0.170)	(0.255)	(0.255)	(0.002)	(0.002)	(0.002)	(0.003)
Firm age	0.112**	0.112**	0.068	0.074	0.009**	0.008**	−0.015**	−0.015**
	(0.043)	(0.043)	(0.053)	(0.053)	(0.000)	(0.000)	(0.000)	(0.000)
Firm size	0.600**	0.598**	0.790**	0.786**	0.027**	0.027**	0.044**	0.044**
	(0.170)	(0.164)	(0.203)	(0.196)	(0.000)	(0.000)	(0.000)	(0.000)
ROA	−0.406	−0.375	−0.426	−0.446	1.662**	1.661**	1.900**	1.900**
	(0.706)	(0.713)	(0.704)	(0.702)	(0.015)	(0.015)	(0.017)	(0.018)
Market to book ratio	0.014	0.008	0.014	0.010	−0.029**	−0.029**	−0.047**	−0.047**
	(0.034)	(0.033)	(0.039)	(0.037)	(0.001)	(0.001)	(0.001)	(0.001)
Unabsorbed slack	0.009	0.012	−0.032	−0.032	0.008**	0.008**	0.002*	0.002*
	(0.042)	(0.042)	(0.046)	(0.045)	(0.001)	(0.001)	(0.001)	(0.001)
Potential slack	−0.019	−0.020	−0.060	−0.062	−0.003**	−0.003**	−0.001	−0.001
	(0.024)	(0.025)	(0.043)	(0.043)	(0.000)	(0.000)	(0.000)	(0.000)
Cumulative number of patents	0.000	−0.000	−0.002**	−0.002**	−0.000**	−0.000**	−0.000**	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Government experience	−0.019	0.020	0.494**	0.522**	0.151**	0.151**	0.206**	0.206**
	(0.205)	(0.196)	(0.163)	(0.170)	(0.003)	(0.003)	(0.004)	(0.004)
Independent director	1.334*	1.310*	0.992	0.948	0.433**	0.434**	0.183**	0.183**
	(0.609)	(0.598)	(0.637)	(0.626)	(0.005)	(0.005)	(0.006)	(0.006)
CEO and chairman duality	0.063	0.071	−0.057	−0.035	−0.078**	−0.077**	−0.042**	−0.042**
	(0.137)	(0.137)	(0.155)	(0.155)	(0.001)	(0.001)	(0.002)	(0.002)
CEO salary	0.000	0.000	0.000	0.000	0.000**	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province GDP per capita	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province R&D expenditure	0.000^{+}	0.000	0.000*	0.000^{+}	0.000**	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province market development	0.101	0.138	0.157^{+}	0.215*	0.011**	0.012**	−0.021**	−0.021**
	(0.093)	(0.099)	(0.095)	(0.097)	(0.000)	(0.000)	(0.000)	(0.000)
Firm fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	3,676	3,676	2,539	2,539	6,622	6,622	3,324	3,324
Log pseudolikelihood	−7499	−7478	−5725	−5704	−1117	−1117	−807	−807

Robust standard errors are in parentheses. All tests are two-tailed and include constant. $^{**}p < 0.01$, $^{*}p < 0.05$, $^{+}p < 0.1$

Table 5. Effects of Post-Policy, Board Share, and Government Quality on Quantity and Novelty of Patents

Model	5-1	5-2	5-3	5-4	5-5	5-6
	FE Poisson	FE Poisson	FE Poisson	Tobit (firm FE)	Tobit (firm FE)	Tobit (firm FE)
DV	Number of patents	Number of patents	Number of patents	Proportion of novel patents	Proportion of novel patents	Proportion of novel patents
Sample (both treatment and control groups included)	**Subsample of firms in provinces with low gov quality**	**Subsample of firms in provinces with high gov quality**	**All samples**	**Subsample of firms in provinces with low gov quality**	**Subsample of firms in provinces with high gov quality**	**All samples**
Government quality ×Proportion of board share × Post policy			0.154			2.336**
			(0.153)			(0.001)
Proportion of board share × Post policy	−0.045	−0.137	−0.280	−0.113**	6.337**	−0.600**
	(0.116)	(0.126)	(0.179)	(0.005)	(0.000)	(0.000)
Government quality ×Proportion of board share			−0.240			−2.387**
			(0.167)			(0.001)
Government quality × Post policy			0.222+			−0.010**
			(0.116)			(0.003)
Government quality			−0.055			0.073**
			(0.061)			(0.002)
Proportion of board share	0.131	0.110	0.375+	0.032**	−6.347**	0.647**
	(0.121)	(0.107)	(0.219)	(0.003)	(0.000)	(0.000)
Post policy	0.443*	0.468**	0.337*	0.071**	0.078**	0.108**
	(0.188)	(0.126)	(0.145)	(0.003)	(0.003)	(0.003)
Proportion of state share	0.320	0.340	0.446**	−0.052**	0.468**	0.214**
	(0.283)	(0.318)	(0.170)	(0.003)	(0.002)	(0.002)
Firm age	0.074	0.193**	0.111*	−0.010**	0.048**	0.006**
	(0.059)	(0.072)	(0.043)	(0.000)	(0.000)	(0.000)
Firm size	0.546**	0.750**	0.592**	0.094**	−0.016**	0.026**
	(0.174)	(0.244)	(0.165)	(0.000)	(0.000)	(0.000)
ROA	−2.002*	0.919	−0.288	0.841**	2.482**	1.598**
	(0.983)	(1.136)	(0.676)	(0.019)	(0.021)	(0.015)
Market to book ratio	0.014	0.038	0.006	0.020**	−0.063**	−0.032**
	(0.055)	(0.038)	(0.033)	(0.001)	(0.001)	(0.001)
Unabsorbed slack	0.101+	0.013	0.010	0.031**	−0.019**	0.008**
	(0.052)	(0.090)	(0.043)	(0.001)	(0.001)	(0.001)
Potential slack	−0.111**	−0.006	−0.021	−0.002**	−0.002**	−0.003**
	(0.032)	(0.009)	(0.025)	(0.001)	(0.000)	(0.000)
Cumulative number of patents	0.000	−0.002**	−0.000	−0.000**	−0.001**	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Government experience	0.122	0.611*	0.016	0.279**	0.145**	0.149**
	(0.220)	(0.268)	(0.198)	(0.004)	(0.003)	(0.003)
Independent director	2.606**	0.196	1.306*	0.725**	−0.407**	0.455**
	(0.898)	(0.809)	(0.593)	(0.006)	(0.006)	(0.005)
CEO and chairman duality	0.144	−0.199	0.064	−0.101**	−0.045**	−0.081**
	(0.168)	(0.122)	(0.138)	(0.002)	(0.002)	(0.001)
CEO salary	−0.000	0.000	0.000	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province GDP per capita	0.000	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province R&D expenditure	−0.000**	0.000**	0.000	−0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province market development	−0.000	0.147	0.143	−0.018**	0.039**	0.014**
	(0.087)	(0.136)	(0.100)	(0.000)	(0.000)	(0.000)
Firm fixed effects	YES	YES	YES	YES	YES	YES
Observations	1,525	1,822	3,676	3,263	3,359	6,622
Log pseudolikelihood	−2796	−3348	−7456	−422	−577	−1113

Robust standard errors are in parentheses. All tests are two-tailed and include constant. **p < 0.01, *p < 0.05, +p < 0.1

Table 6. Effects of Post-policy, State Share, and Government Quality on Quantity and Novelty of Patents

Model	6-1	6-2	6-3	6-4	6-5	6-6
	FE Poisson	FE Poisson	FE Poisson	Tobit (firm FE)	Tobit (firm FE)	Tobit (firm FE)
DV	Number of Patents	Number of Patents	Number of Patents	Proportion of Novel Patents	Proportion of Novel Patents	Proportion of Novel Patents
Sample (both treatment and control groups included)	**Subsample of firms in provinces with low gov quality**	**Subsample of firms in provinces with high gov quality**	**All samples**	**Subsample of firms in provinces with low gov quality**	**Subsample of firms in provinces with high gov quality**	**All samples**
Government quality × Proportion of state share × Post policy			−0.511**			−0.003
			(0.195)			(0.015)
Proportion of state share × Post policy	0.307	−0.325	0.133	0.334**	0.291**	0.301**
	(0.496)	(0.317)	(0.353)	(0.011)	(0.013)	(0.011)
Government quality × Proportion of state share			0.079			−0.007
			(0.156)			(0.007)
Government quality × Post policy			0.283*			0.015**
			(0.130)			(0.003)
Government quality			−0.092			0.047**
			(0.078)			(0.002)
Proportion of state share	0.110	0.488	0.377	−0.184**	0.389**	0.137**
	(0.451)	(0.384)	(0.334)	(0.007)	(0.009)	(0.008)
Post policy	0.391*	0.522**	0.302*	0.032**	0.084**	0.066**
	(0.185)	(0.153)	(0.145)	(0.003)	(0.003)	(0.003)
Proportion of board share	0.109	−0.015	0.024	−0.052**	−0.016**	−0.030**
	(0.086)	(0.067)	(0.058)	(0.002)	(0.000)	(0.000)
Firm age	0.078	0.184**	0.110*	−0.008**	0.054**	0.009**
	(0.059)	(0.070)	(0.043)	(0.000)	(0.000)	(0.000)
Firm size	0.525**	0.759**	0.598**	0.081**	−0.033**	0.022**
	(0.177)	(0.243)	(0.169)	(0.000)	(0.000)	(0.000)
ROA	−1.970*	0.883	−0.446	0.864**	2.606**	1.668**
	(0.988)	(1.122)	(0.684)	(0.019)	(0.021)	(0.015)
Market to book ratio	0.013	0.041	0.007	0.018**	−0.062**	−0.029**
	(0.055)	(0.038)	(0.033)	(0.001)	(0.001)	(0.001)
Unabsorbed slack	0.103*	0.016	0.011	0.032**	−0.018**	0.008**
	(0.051)	(0.088)	(0.042)	(0.001)	(0.001)	(0.001)
Potential slack	−0.111**	−0.006	−0.021	−0.002**	−0.002**	−0.003**
	(0.032)	(0.009)	(0.025)	(0.001)	(0.000)	(0.000)
Cumulative number of patents	0.000	−0.001**	0.000	−0.000**	−0.001**	−0.000**
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Government experience	0.119	0.621*	0.006	0.275**	0.149**	0.146**
	(0.223)	(0.267)	(0.196)	(0.004)	(0.003)	(0.003)
Independent director	2.640**	0.265	1.337*	0.722**	−0.394**	0.427**
	(0.907)	(0.778)	(0.633)	(0.007)	(0.006)	(0.005)
CEO and chairman duality	0.156	−0.225^{+}	0.066	−0.105**	−0.051**	−0.080**
	(0.170)	(0.132)	(0.139)	(0.002)	(0.002)	(0.001)
CEO salary	−0.000	0.000	0.000	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province GDP per capita	0.000	−0.000**	−0.000**	−0.000**	−0.000**	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province R&D expenditure	−0.000**	0.000**	0.000	−0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Province market development	0.008	0.151	0.141	−0.016**	0.028**	0.013**
	(0.087)	(0.134)	(0.097)	(0.000)	(0.000)	(0.000)
Firm fixed effects	YES	YES	YES	YES	YES	YES
Observations	1,525	1,822	3,676	3,263	3,359	6,622
Log pseudolikelihood	−2794	−3346	−7465	−422	−580	−1115

Robust standard errors are in parentheses. All tests are two-tailed and include constant. $^{**}p < 0.01$, $^{*}p < 0.05$, $^{+}p < 0.1$

Appendix

Table A1. Industrial categories of products listed in the government procurement catalogs

Industrial category	Percentage
Agriculture	2.41
Animal Husbandry	0.37
Fishery	0.90
Education, Cultural, Sporting and Athletic Goods Manufacturing	0.02
Raw Chemical Materials and Chemical Products	16.20
Chemical Fiber Manufacturing	3.40
Electronic Components and Appliance	5.99
Consumer Electronics Manufacturing	1.49
Other Electronic Equipment Manufacturing	0.73
Non-Metallic Mineral Products	7.25
Ferrous Metal Smelting and Extruding	7.07
Special Equipment Manufacturing	11.68
Transportation Equipment Manufacturing	13.29
Electrical Machinery and Equipment Manufacturing	5.42
Instrumentation and Manufacturing of Machinery for Education and Cultural Uses	0.90
Pharmaceutical Manufacturing	9.66
Biological Products Manufacturing	2.00
Telecommunications and Related Equipment Manufacturing	4.89
Computer and Related Equipment Manufacturing	1.79
Telecommunication Services	0.80
Computer Application and Services	3.74

Note: The second column reports the proportions of patents that belong to each category generated by all Chinese firms between 2000 and 2012.