Enterprise innovation in China: Does ownership or size matter?

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Abstract

Innovation capability of enterprises is one of the prime focuses of China as it fosters an innovation-driven growth model in the period of 'new normal'. This research examines the effects of ownership and size on firm innovation capacity, using the World Bank China Enterprise Survey (2012). Unlike most existing studies, where these two important aspects of innovation were delved separately, this paper analyses the effects in unison, based on survey data approach with different dimensions added (city, industry fixed) and the interaction of ownership and size variables. Major findings suggest that SOEs and domestic private enterprises are much alike in innovation participation, but different in innovation diversification that leads to ownership-specific innovative advantages. SOEs seem to be stronger in process innovation in general. Foreign enterprises are more innovative in most of the innovation measurements. Size is positively correlated to innovation. We also find that as the size of enterprise increases, ownership- specific innovative advantage is subject to change. That implies that ownership and size should be examined jointly rather than separately. The result also shows the effects of ownership and size on innovations are uneven geographically and by industry.

JEL codes: L25, O32, O33

1. Introduction

China has been installing an innovation-driven development model since 2006. In recent years, as traditional driving force of fast economic growth is fading away, China enters the so-called stage of economic 'New Normal'[1]. Against this background, industrial innovation is deemed as the key solution to new development model. As the main locus of technological innovation, the enterprises' performance in innovation is now in the spot light. As stated by Cohen (2010), there are many determinants to enterprise innovation, such as market competition, size of the firms, financial support, intellectual property protection, etc. However, some latest trends in China intrigue our interest in the role of ownership and size of Chinese enterprises in innovation.

On the aspect of the linkage of ownership and innovation, Chinese State Owned Enterprises (SOEs) still have significant influence on national economy. Major SOEs reform has taken place under the policy guideline of 'seize the big and free the small' (*zhuada fangxiao*)[2] since mid-1990s. Nevertheless, some short-listed SOEs in selected key sectors were left under the control of government, while a large number of small- and medium-sized SOEs were privatized in certain deregulated industries. When China launched a new development strategy focusing on innovation in 2006, indigenous innovation capability of domestic enterprises has been highlighted. As an important tool of China's industrial policy, SOEs at various governmental levels[3] are incentivized to initiate cooperate strategies that stress innovation, with state support and supervision. For example, there was not any incentive scheme for top managers of SOEs who carry out innovation in the first version of operating performance assessment of State-owned Assets Supervisor and Administration Commission of the State Council (SASAC)[4] that implemented in 2004. However, the rewards for SOEs top managers who achieve innovation outcomes has been added in 2007 amendment and highlighted in the latest 2012 and 2016 amendments. In recent years, some Chinese SOEs dominated technologically advanced industries demonstrating impressive international competitiveness, such as high-speed railways, nuclear power generation, aerospace industries. these achievements have rejuvenating the social image of SOEs. However, it is an imperative to see if these Chinese SOEs are advantageous in innovation.

Analysis on the SOEs performance is not simple. On the one hand, based on theoretic predictions like multiple principle-agent chain, SOEs are criticized for lower efficiency in economic performance, compared to their private counterparts because of lack of necessary incentives. On the other hand, SOEs are usually better equipped financially and have more resources to invest in

[1] 'New normal' refers to Chinese government's attempt to rebalance the economy to slower but more sustainable economic development.

[2] The first wave of 'seize the big and free the small' in SOEs was in 1995, when the CPC (Communist Party of China) Central Committee proposed official suggestion for the 9th national Five-Year-Plan for economic and social development, with emphasize on stricter control of a certain cohort of big enterprises and business conglomerates. This reform was reinforced in 2003 during 3rd session of the 16th CPC National Congress, which set a policy target to develop internationally competitive big state owned enterprises and conglomerates.

[3] Chinese SOEs are affiliated to different levels of government according to sources of state shares. For example, central government invested SOEs are termed as central SEOs. Likewise, there are also provincial SOEs, ministerial SOEs, municipal SOEs, etc.

[4] SASAC is the ministerial department under the State Council of People Republic of China, founded in 2003. As the representative of central government in state-owned assets, the major obligations of SASAC covers supervision and administration of top managers, governance structure, assets operation of key SOEs. The policies and regulations of SASAC are often acting as the guidelines for sub-national governments' division likewise.

innovation, and they have better skill development institutions for employees, which are in favor of innovation. Therefore, empirical research for this is desirable to assess the capability of SOEs' innovation.

Besides SOEs, Chinese non-state sector is also at high attention in terms of innovation (Brandt and Zhu, 2010). Firstly, after the reform of 1978, large number of foreign companies began to invest in China as joint venture institutions, the trend which still continues. These foreign companies are an important source of technological change and productivity growth (Liu and Buck, 2007; Fu et al. 2011) since China was technologically backward during that time. There are evidences that there have been knowledge and managerial spillovers from these joint ventures to domestic partners. As these enterprises are closing technological gaps with global leading counterparts, the contribution of foreign invested companies to China's innovation has been in limelight. Secondly, domestic enterprises are also becoming more active as Chinese private sector grows, especially in the deregulated and emerging industrial sectors where SOE influence is absent or minor. Some of these sectors where in domestic private enterprises are playing the leading role in pushing forward the technological frontier are information and telecommunication equipment, solar voltaic manufacturing and new energy vehicles. With regard to the relationship between the size of a firm and innovation capacity of Chinese firms, there are some deliberations in recent policies. As an outcome of industrial organization policy that aims to strengthen state's regulation in industrial investment and production, intra-industry integration between Chinese giants is causing public debates.[5] Advocates claim that bigger enterprises have innovative advantages, due to their strong capability in mobilizing resources, market competition, and manufacturing functions, which generate increasing returns. Big enterprises are enjoying unproportioned resources by discriminative policies that are size-based. Given that SOEs are normally big enterprises, policy preference towards state share and big size is used to be reinforced inertly. However, some Chinese start-ups which grew to be national or even global key players in a rather short period of time demonstrate the spirit of 'small is beautiful'. Chinese policy makers are becoming aware of the dynamic innovation capability of small business and entrepreneurship. Since 12th five year plan (2010-2015), a policy supportive towards small business has been adopted that channels social resources, both public and private. Therefore, a study that looks into the aspects of size of Chinese firms and its innovation capacity would be very useful for reviewing the effects of Chinese industrial organization policy.

In this paper, we look into the various aspects of ownership and size from the perspective of Chinese firms. In contrast to previous research, where these two important aspects of innovation were delved separately, this paper analyses the effects in unison by using the most comprehensive data on Chinese enterprises- World Bank China Enterprise Survey (2012), which contains detailed data on firm features from different cities. We use various dimensions of innovation performance, including the probabilities of R&D expenditure, staff training, product innovation, process innovation and management innovation. Our key variables of interest are ownership based on largest share (SOE, private and foreign) and firm size based on the number of employees. The analysis is based on firm-wise cross section data approach with different fixed

[5] In recent years, the cases of merger and acquisition between big SOEs is increasing, including M&A in rail transportation equipment, steel, hydro-power, nuclear power, mining, construction material, etc.

effects (city, industry fixed) and the interaction of ownership and size variables. Results suggest that foreign firms are the most innovative and SOEs the least. We also find that large firms are more innovative than small and medium counterparts. In terms of investment in R&D, large firms invest significantly higher (52%) compared to Medium (41%) and small (29%) businesses. Further, we find that Chinese SOEs are better in providing technological training for staff and reducing production cost. However, they are not competitive to private firms in other dimensions of innovation.

Rest of the paper is structured as follows. In the next section, we review the existing literature on the subject matter. In section 3, we present research methods followed by results and discussion in section 4. Section 5 concludes.

2. Literature Review

Countries vary in their R&D and innovation capabilities primarily owing to diversified institutional settings. In Anglo- American model, dispersed ownership, equity- based financing and strong role for corporate control play a vital role whereas German- Japanese model is characterized by long- term bank finance, concentrated large block holder ownership and insider based control mechanisms (Choi et al., 2011). A stream of literature focuses on the role of institutions on innovation at a broad/macro sense (Soskice, 1997), or takes an approach of innovation systems at national (Lundvall, 1992; Freeman, 1995; Nelson, 1993), regional (Cook et al., 1997), or sectoral (Malerba and Orsenigo, 1997) levels. At the broad/macro level, innovation is critical to attain economic growth in the long run. Another stream of literature takes a narrow/micro perspective to explore which institutional arrangements are most conductive to innovation. In this setting, innovation of firm is related to the aspects of information and incentive of organization (Azoulay and Lerner, 2013). This leads to a recurrence of the research on enterprise innovation and latest development of firm theories since 1990s, which shed lights on the relations between nature (ownership) and boundary (size) of a firm and innovation.

2.1 Ownership and Innovation

Innovation is costly, risky and investment specific, hence, the ownership of the firm is highly relevant to innovation incentive and governance (Aghion and Tirole, 1994). Different firm theories (agency theory, transaction cost theory, and the new property right theory) have different implications for innovation (Francis and Smith, 1995; Ortega et al., 2005). For example, Grossman-Hart-Moore (hereafter, GHM) Model (Grossman and Hart,1986; Hart and Moore,1990) suggests that the ownership of firm has strong influence on incentive on the ex-ante investment decisions of the firm. This is because the ultimate 'residual decision right' arising due to the discrepancy in the contract theory lies in the hands of the owner. These decisions could relate to R&D expenditure and thereby innovation capability of firms.

The effect of ownership variation on enterprise innovation is more complex for transition economies like China, wherein the change in the governance of ownership is the key for SOEs reform. Choi et al. (2011) used the sample of 548 publicly traded Chinese firms for year 2001 in eight industries and found that firms with foreign ownership along with business group affiliation are more innovative than others; whereas state and institutional ownership have positive influence

but with lagged effect. However, insider ownership has negative influence and ownership concentration is not significant. Jefferson et al. (2003) investigated the innovation capability of China's 22,000 large- and medium-sized enterprises that underwent ownership diversification during 1994-1999 SOEs reforms, and concluded that R&D intensity of input and outputs became more intensive during this period. Xu and Zhang (2008) investigated 541 publicly traded companies in 5 high-tech industries during 2000-2005 and found that the presence of state shares has a positive effect on enterprises' process innovation strategy over product innovation. Guan et al. (2009) used a sample of 1244 Chinese firms in Beijing and found that firm size explains innovation rate and innovation sales, while types of ownership (SOE or others) is not significant. Lin et al. (2011) found that sales-based performance incentive schemes for CEOs are more conducive than the ones with profit-based in increasing corporate innovation effort and performance in China's private sector. Boeing et al. (2016) consider the ownership structure in three aspects: Privately owned enterprises (POEs), majority SOEs and minority SOEs. The authors analyzed whether the rise in R&D activities has a positive and sustained effect on total factor productivity (TFP) in Chinese listed firms (Shanghai and Shenzhen) across two time periods: 2001- 2006 and 2007- 2011. They found that the effectiveness of R&D activities is increasing over time for POEs compared to other two types of SOEs. POEs also obtain higher returns from their own high quality R&D activities thereby stimulate the leading position in the industry and higher profits, compared to SOEs. The authors also noted that minority SOEs follow commercially oriented patenting strategy than policy induced.

Several studies consider the role of foreign direct investment (FDI) on the innovation capability of countries (at macro level) and of firms (at micro level), such as Branstetter, 2001 (for US and Japan); Cheung and Lin, 2004 (for China at provincial level); Blind and Jungmittag, 2004 (for service sector); Peri, 2005 (for Europe and North America); Liu and Zou, 2008 (for Chinese high-tech industries); Lin and Lin, 2010 (for Taiwan); Ito et al., 2012 (for China); Huang et al. 2012 (for China at provincial level); Erdal and Gocer, 2015 (for developing Asian economies).

AlAzzawi (2012) investigated the effect of knowledge transmitted through FDI on the production of knowledge in both source and recipient countries. By categorizing the countries as technology leaders and technology followers, the author show that both inward and outward FDI is significantly important in followers' innovation abilities. As one of the most attractive destination of FDI, the role of the foreign investment in Chinese enterprise innovation is securitized (Cheung and Lin, 2004; Liu and Zou, 2008; Lin and Lin, 2010; Ito et al., 2012; Huang et al., 2012). Hu et al. (2003) examine the three avenues of technological advance within Chinese industry and found FDI does not facilitate the adoption of market-mediated foreign technology transfer. Jefferson et al. (2004) found no significant difference in R&D expenditure intensity across various ownerships for big-and-medium sized manufacturing firms from 1997-1999. Liu and Buck (2007) found that the R&D activities by multinational enterprises in Chinese high-tech industries significantly affect the innovation performance of domestic firms through a mechanism of learning-by-exporting (and importing). Girma et al. (2009) investigated such relationship for about 20,000 Chinese SOEs by using firm level data for period 1999-2005. By using general production function and GMM estimation, the authors found that inward foreign capital participation at the firm level is highly associated with higher innovative activity. However, at

sector-level, such participation has negative effect but has positive effect on SOEs which are export oriented, invested in human capital or have prior experience in R&D.

2.2 Firm size and Innovation

Literature on the innovation capability in relation to firm size largely revolves around the idea of Schumpeter's 'Creative Destruction'. Schumpeter (1942) hypothesized that innovative activity is promoted by large firms and by imperfect competition. He stated that larger firms with some degree of monopolistic power could be more innovative than others because of the access to better resources and market (Kamin and Schwarz, 1975; Chandler et al., 1997). Over the time, this hypothesis was empirically challenged by various quantitative studies being studied over different countries, industries, variables and econometric specifications.

The advantage of big firms in innovation is supported theoretically and empirically (Fisher and Temin, 1973; Link, 1980; Cohen and Levin, 1989; Cohen, 1995; Cohen and Klepper, 1996; Legge, 2000). However, there are studies that counter this hypothesis wherein they have found variability in the innovative activities across large and small firms (Mansfiled, 1964; Scherer, 1965; Comanor, 1967; Jaffe, 1988; Kohn and Scott, 1982; Cohen et al., 1987). Some literatures found that the relationship between firm size and innovation is non-linear ('U-shaped' or inverted 'U-shaped') (Scherer, 1965; Grabowski, 1968; Soete, 1979; Scherer, 1980; Kamien and Schwartz, 1982), due to the fact that innovative advantage of firms of different sizes is industry specific, or the new division of innovative labor between big and small businesses (Teece, 1986; Arora et al., 2002). Acs and Audretsch (1987, 1988) used the difference between the large-firm innovation rate and the small-firm innovation rate as the dependent variable and found that both large and small firms could be innovative depending upon their characteristics. Large firms tend to have the relative innovative advantage in industries which are capital-intensive, concentrated, and advertising-intensive. Conversely, small firms tend to have the relative advantage in industries which are in the early stages of the life-cycle, where total innovation and the use of skilled labor play a larger role, and where large firms comprise a high market share. Arvnitis (1997) investigated the impact of firm size on innovation activity with the survey data of Swiss manufacturing firms, both for product and process innovation. The author found positive significant result for firm size in linear term, but there is also significant negative result for firm size in quadrative term, indicating inverted U-shaped phenomenon in innovation activity. The author also found similar pattern in industry level analysis. The author concludes that there is size- specific orientation of innovative activity depending upon different environment.

In the case of Chinese enterprises, using 813 high- tech firms in Beijing, Hu (2001) found that size is positively related to innovation. Jefferson et al. (2004) found no significant effect of firm size on R&D intensity for Chinese big-and-medium sized firms, after controlling for industrial effects. Yam et al. (2004) concluded that different technological innovation capabilities lead to different performance for big-and-medium sized firms and small firms in Beijing. Tsai and Wang (2005) used sample of publicly listed 126 Taiwanese manufacturing firms and found the 'U-type' relationship between R&D productivity (R&D elasticity) and firm size. In general, the Chinese experience on the relation between the size of firm and innovation capacity is still not clear.

Size and ownership are important determinants for enterprise innovation, although no general conclusions have been reached. Nevertheless, pervious research has often examined their effects on innovation separately. This situation leaves room for further study of the Chinese enterprise innovation. First, as mentioned above, China's reform in SOEs has been size-based, which leads to a joint effect of state ownership and size on innovation. Second, innovation supporting system, such as innovation financing, national key scientific and innovation projects, is preferential towards domestic and big enterprises, which would leads to an upward bias of innovation policy targeting. Third, Chinese enterprises of different ownership may set different priorities in their innovation efforts. In this paper, we use the World Bank enterprise survey dataset that is capable in examining jointly the effects of ownership and size on various innovation patterns. By so doing, we give a clearer picture of enterprise innovation in China, which is actively promoting enterprise innovation through preferential policies.

3 Research design and data

3.1 Research design

This research focuses on empirical test of the effects of ownership and size on innovation.

We measure the innovative capacity of the firm on two specific dimension: innovation specialization and innovation diversification. Innovation specialization is based on OECD/Eurostat Oslo Manual. According to the manual the innovation could be achieved in four aspects: product innovation, process innovation, management innovation and promotion innovation. Therefore, innovation specialization includes these four components. Innovation diversification is measured by counting how many types of innovation among above mentioned innovation aspects a firm has achieved. It is a single variable.

In order to capture enterprise's all-around innovation capacity, we follow the standard innovation measurements of OECD/Eurostat Oslo Manual, 2005. According to the manual, innovation includes product innovation, process innovation, management innovation and promotion innovation. Based on this innovation measurement, we further define the dependent variable *innovation* in two dimensions, the innovation specialization (*innovativeness*) as a firm carries out any one type of four innovations, and innovation diversification (*innovation scope*) by counting how many types of innovation a firm achieved.

Innovation variables include *innovativeness*, *product innovation*, *process innovation*, *management innovation* and *promotion innovation* that take value of 0 or1, therefore we use the standard Probit model as following.

$$\ln \frac{q_i}{1-q_i} = c_1 + c_2 * ownership \quad + c_3 * size \quad + C * X + \emptyset \tag{1}$$

Where q_i is the probability the firm achieved innovation activity i, where i is one of the dummy labeled innovation variables. *Ownership* includes state owned, private owned as well as foreign

owned. *Size* is measured by firm's employees and managers. X is a set of control variables, including industry fixed effects and city fixed effects. $\emptyset$ is the random error term.

For the variable *scope*, we use the Poisson estimation approach since innovation scope take 0,1,2,3,4 values, bearing the count data feature. The model is set as followings.

$$\mathrm{Ln}\mu_i = d_1 + d_2 * ownership_i + d_3 * size + D * X + \varsigma_i \quad (2)$$

Where μ_i is the mean of innovation count y_i (y_i=0,1,2,3,4) where y_i follows Poisson distribution (Cameron& Pravin, 1998). X refers to the city and industry fixed effects. ς_i is the random error term.

3.2 Data

The data is from The World Bank China- Enterprise Survey (2012). The World Bank enterprise surveys are conducted across all geographic regions and cover small, medium, and large companies. The surveys are administered to a representative sample of firms in the non-agricultural formal private economy. Data are used to create indicators that benchmark the quality of the business and investment climate across countries. The World Bank China - Enterprise Survey (2012) was carried out in China between December 2011 and February 2013. Data was collected from 2,700 privately-owned and 148 state-owned firms. Normally, enterprise surveys in other countries are conducted in private sector. But for China, a special sample of SOEs is covered in the survey, to track changes in the Chinese business environment over time. This survey covers geographically twenty-five metro areas: Beijing (municipality), Chengdu City, Dalian City, Dongguan City, Foshan City, Guangzhou City, Hangzhou City, Hefei City, Jinan City, Luoyang City, Nanjing City, Nantong City, Ningbo City, Qingdao City, Shanghai (municipality), Shenyang City, Shenzhen City, Shijiazhuang City, Suzhou City, Tangshan City, Wenzhou City, Wuhan City, Wuxi City, Yantai City, Zhengzhou City. Note that those cities are not randomly sampled, but are selected based on the number of establishments, contribution to employment, and value added. It is easy to read from Figure 1 that China is centered economically in the east regions (red) of Yangtze River Delta Economic Zone, Pearl River Delta Economic Zone and the Bohai Economic Rim. Middle region (green), Northeast (orange) and West (blue) are relatively economically backward. Hence, the survey represents the first-tier Chinese enterprises.

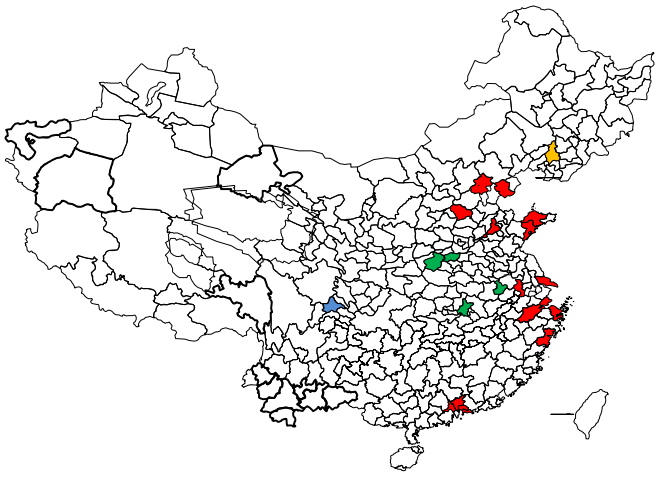

Figure 1 Geographic Coverage of The World Bank China - Enterprise Survey

Note: Survey covered cities are in 4 different colors illustrating their regional economic identifies: red for 'East', green for 'Middle', blue for 'West', and orange for 'Northeast.

The dataset has rich information in firm features, such as innovation activities, ownership, size, location and industry, which is capable to support our investigation on the effects of ownership and size on innovation. Different from conventional measurements of innovation, this survey captures the innovative efforts and actions directly, rather than using proxies like patenting. Following the Oslo manual, we measure firm's all around innovation capacity through including product innovation, process innovation, management innovation as well as promotion innovation. For product innovation, if the firm answer 'yes' (instead of 'no') to the question 'Over the last three years, has this establishment engaged in introducing new product or new service', we define the firm as product innovation firm, otherwise as non-product innovation firm. Similarly, we define firm answering 'yes' (instead of 'no') to the question 'Over the last three years, has this establishment engaged in taking measures to reduce production cost' as process innovation firm; define firm answering 'yes' (instead of 'no') to the question 'Over the last three years, has this establishment engaged in introducing new managerial/administrative processes' as management innovation firm. For promotion innovation, we define firm answering 'frequently' or 'all the time' (instead of 'rarely', 'sometime') to the question 'To what extent are information and communication technologies (computers, internet, and software) used to support marketing and sales?' as promotion innovation firm. Based on these four types of innovation measurements, we use a dummy variable innovativeness, it takes 1 if the firm engaged in at least one type of innovation activities, otherwise 0. Further, we use a variable innovation scope, recording the total number of innovation type the firm engaged.

Two key explanatory variables are ownership and firm size. For ownership, we define a category variable, the firm is denoted as SOE if the state/government is the largest shareholder. We denote firm as private (or foreign) if the largest shareholder is private domestic individuals, companies or organizations (or private foreign individuals, companies or institutions). We measure firm size using the number of permanent, full-time individual worker (in the natural logarithm form) of this

establishment. Since most of innovation variables are referred to the last past three years, we take the number of permanent, full-time workers by the end of fiscal year 2008.

Table 1 Summary Statistics of Key Variables

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Innovativeness	2723[6]	0.77	0.42	0	1
Innovation scope	2723	1.62	1.37	0	4
Product innovation	1641	0.53	0.50	0	1
Process innovation	1643	0.75	0.43	0	1
Management innovation	1645	0.47	0.50	0	1
Promotion innovation	2685	0.57	0.50	0	1
Ownership	2723	1.18	0.54	1	3
Size	2723	229.68	1443.30	2	50000

Note: calculated with the complete sample in the main regression. city and industry variables are not listed. For variable ownership, 1,2,3 represent private,SOE and foreign enterprise,respectively.

Table 1 lists the descriptive summary statistics for key variables. Nearly 77% of firms reported that they achieved at least one type of innovations. On average, the surveyed firm says they took 1.62 types of innovations. Comparatively, the participation rate for process innovation rates is the highest, reaching 75%, followed by promotion innovation (57%), product innovation (53%) and management innovation (47%). Among the 2723 firms, private firms take a share of 89.46%, followed by SOE (7.42%) and foreign firms (3.12%). The size of firm varies a lot, with the minimal of 2 employees and maximal of 50000 employees. The sample used covers 25 cities, including Beijing, Guangzhou, Hefei, Chengdu, etc. Finally, the sample used spans in 24 2-digit industries, including plastics & rubber, machinery and equipment, textiles, etc.

4. Empirical Results

4.1 Base Model

We present our baseline estimation in Table 2. Column (1) shows that there is no significant difference between domestic private firms and SOEs in terms of *innovativeness*. It implies that innovation prevails for enterprises of different ownerships, even for the SOEs that are often viewed less efficient in resource allocation, including innovation. This finding is likely to reflect one of the outcomes of China's SOEs reforms. After the policy that promotes SOEs to adopt the 'modern enterprise system' since 2000, more than 90 per cent Chinese SOEs have accomplished corporate or shareholding reforms, and most of them have adopted a sound corporate structure by

[6] *Innovativeness* is calculated according to product innovation, process innovation, management innovation and promotion innovation. If an enterprise reported yes to product innovation, but report "missing" for process innovation, the enterprise will be recorded as yes for innovativeness , but missing for process innovation. Therefore, the sample size is larger for innovativeness. It also applies to *innovation scope*.

establishing institutions like boards of shareholders, directors, supervisors, managers.[7] As the consequence, SOEs are operating like private businesses, especially when the importance of innovation is now a vital factor for enterprise competitiveness. Policy that encourages SOEs to practice innovation also increases their participation rate in innovation. However, the estimation result provides strong evidence that the bigger firms have innovative advantages.

Although SOEs are not invariant in innovation participation, column 2 shows that SOEs are less likely to engage in innovation diversification. More specifically, SOE is less innovative in terms of product innovation, organization innovation and promotion innovation (column (3), (5) and (6)), compared to private firms; nevertheless, SOEs show stronger capability in process innovation than private firms. Meanwhile, the results consistently demonstrate that firm size is positively correlated with innovation, in almost all innovation dimensions.

Table 2 Effects of Ownership and Size on Innovation

	innovativeness (1)	*scope* (2)	*product* (3)	*process* (4)	*organization* (5)	*promotion* (6)
SOE	0.101	-0.350***	-1.006***	0.951***	-0.707***	-0.499***
	(0.165)	(0.073)	(0.198)	(0.284)	(0.221)	(0.132)
Foreign	0.270	0.170***	0.244	0.385*	0.359**	0.321**
	(0.229)	(0.047)	(0.180)	(0.200)	(0.175)	(0.148)
SIZE	0.227***	0.118***	0.145***	0.210***	0.241***	0.151***
	(0.026)	(0.009)	(0.026)	(0.032)	(0.028)	(0.021)
_cons	1.213***	0.386***	-0.450**	0.606**	-2.106***	0.036
	(0.249)	(0.071)	(0.221)	(0.306)	(0.243)	(0.185)
City	Yes	yes	yes	yes	yes	yes
industry	Yes	yes	yes	yes	yes	yes
r2_p	0.272	0.172	0.175	0.230	0.168	0.136
Ll	-1063.843	-3740.399	-942.016	-709.079	-951.744	-1594.359
N	2723	2736	1651	1645	1655	2698

Note: Robust standard errors in parentheses. "* p<0.1, ** p<0.05, *** p<0.01" for significance. The base group for ownership is domestic private firm.

4.2 Heterogeneity Effects of Ownership and Size

We go further to examine four types of heterogeneity effects of ownership and size on firm innovation. Firstly, we divide the SOEs into two types, 'pure' SOEs with 100% state share, and mixed-ownership SOEs with controlling state shareholder except 'pure' ones. The result is presented in Panel A and B of Table 3. The result shows that there is insignificant difference between pure SOEs and private firms in almost every aspect of innovation (Panel A). However, for the mixed-ownership SOEs, they are weaker in innovation diversification, product innovation, organization innovation and promotion innovation as compared to private firms (Panel B). This implies that state-private-partnership is favorable towards cost reduction. For both panel A and B, they consistently show that firm size is positively correlated with innovation capacity.

[7] Data is from the paper by the Minister of Industry and Information Technology in 2013.

Table 3 Effects of Ownership and Size on Innovation: Pure and Mixed-ownership

	innovativeness	*Scope*	*product*	*process*	*organization*	*promotion*
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: pure SOE						
SOE	-0.116	-0.227	-0.799	-0.325	0.033	-0.023
	(0.284)	(0.223)	(0.739)	(1.020)	(0.743)	(0.271)
Foreign	0.263	0.171***	0.248	0.357*	0.388**	0.312**
	(0.228)	(0.046)	(0.180)	(0.200)	(0.171)	(0.147)
SIZE	0.235***	0.119***	0.140***	0.212***	0.242***	0.151***
	(0.027)	(0.009)	(0.027)	(0.033)	(0.029)	(0.021)
_cons	1.169***	0.376***	-0.458**	0.601**	-2.153***	0.067
	(0.250)	(0.072)	(0.224)	(0.307)	(0.246)	(0.188)
city	yes	Yes	yes	yes	yes	yes
industry	yes	Yes	yes	yes	yes	yes
r2_p	0.271	0.173	0.162	0.219	0.161	0.131
Ll	-1035.866	-3620.198	-915.549	-703.318	-923.181	-1541.812
N	2628	2639	1585	1579	1589	2604
Panel B: mixed-ownership SOE						
SOE	0.190	-0.374***	-1.055***	1.455***	-0.816***	-0.650***
	(0.212)	(0.077)	(0.207)	(0.432)	(0.233)	(0.153)
Foreign	0.282	0.172***	0.242	0.355*	0.369**	0.332**
	(0.229)	(0.046)	(0.180)	(0.200)	(0.172)	(0.147)
SIZE	0.226***	0.113***	0.157***	0.223***	0.253***	0.154***
	(0.027)	(0.009)	(0.027)	(0.033)	(0.028)	(0.021)
_cons	1.194***	0.409***	-0.497**	0.558*	-2.156***	0.034
	(0.251)	(0.071)	(0.222)	(0.308)	(0.245)	(0.187)
city fixed	yes	Yes	yes	yes	yes	yes
industry fixed	yes	Yes	yes	yes	yes	yes
r2_p	0.272	0.172	0.178	0.236	0.172	0.139
Ll	-1000.620	-3602.931	-926.373	-693.770	-933.598	-1523.963
N	2616	2629	1629	1623	1633	2591

Note: Robust standard errors in parentheses. "* p<0.1, ** p<0.05, *** p<0.01" for significance. The base group for ownership is domestic private firm.

Secondly, we explore the joint effects of ownership and size. Table 4 shows that, on average, SOEs are stronger in terms of process innovation as compared to private firms. However, this effect diminishes with firm size (column (4)). This finding implies SOEs are likely to be affected by the 'big enterprise disease' of increasing management cost erodes production cost reduction as employees grow. One explanation for this change is SOEs are caring more on staff welfare. Foreign firms show stronger capacity in innovation scope, process innovation, organization innovation and promotion innovation as compared to private firms. But this advantage is accompanied by a drastic decrease with firm size.

Table 4 Effects of Ownership and Size on Innovation: Joint Effects

	innovativeness (1)	*Scope* (2)	*product* (3)	*process* (4)	*organization* (5)	*promotion* (6)
*SOE*size*	-0.071	0.025	-0.073	-0.342***	-0.118	-0.076
	(0.067)	(0.031)	(0.088)	(0.105)	(0.100)	(0.057)
*Foreign*size*	-0.221	-0.096***	0.224	-0.247	-0.412***	-0.301**
	(0.171)	(0.036)	(0.186)	(0.174)	(0.151)	(0.118)
SOE	0.380	-0.479***	-0.634	2.528***	-0.166	-0.183
	(0.325)	(0.173)	(0.451)	(0.636)	(0.529)	(0.286)
Foreign	1.214	0.610***	-0.734	1.480*	2.216***	1.641***
	(0.801)	(0.168)	(0.844)	(0.835)	(0.705)	(0.552)
SIZE	0.242***	0.118***	0.147***	0.235***	0.269***	0.170***
	(0.029)	(0.009)	(0.028)	(0.034)	(0.029)	(0.022)
City	yes	Yes	yes	yes	yes	yes
Industry	yes	Yes	yes	yes	yes	yes
_cons	1.155***	0.385***	-0.462**	0.508*	-2.231***	-0.036
	(0.253)	(0.072)	(0.224)	(0.308)	(0.248)	(0.188)
r2_p	0.273	0.172	0.176	0.234	0.172	0.138
Ll	-1062.512	-3738.873	-940.758	-705.343	-946.673	-1590.712
N	2723	2736	1651	1645	1655	2698

Note: Robust standard errors in parentheses. "* p<0.1, ** p<0.05, *** p<0.01" for significance. The base group for ownership is domestic private firm;

Thirdly, we exam whether the effects of ownership and size differ at regional. Firms located in East region are labeled as east group, firms located elsewhere belong to the other regions group. In Table 5 we find evidence that the difference between private firms and SOEs in innovation ability is smaller in East region as compared to firms located elsewhere. Meanwhile, SOEs show similar capacity in organization innovation as that of private firms in East region, wherein market economy is well developed and enterprises of different ownerships are flexible in organizational change. Firm size is positively correlated with innovation activities in both regions.

Table 5 Effects of Ownership and Size on Innovation: Different Regions

	innovativeness (1)	*scope* (2)	*product* (3)	*process* (4)	*organization* (5)	*promotion* (6)
Panel A: East region						
SOE	0.074	-0.238**	-0.815***	0.931*	-0.139	-0.409**
	(0.227)	(0.103)	(0.275)	(0.509)	(0.282)	(0.175)
Foreign	0.168	0.183***	0.286	0.420*	0.326	0.346*
	(0.269)	(0.057)	(0.219)	(0.238)	(0.209)	(0.182)
SIZE	0.241***	0.128***	0.168***	0.245***	0.245***	0.135***
	(0.031)	(0.011)	(0.032)	(0.039)	(0.032)	(0.024)
_cons	-0.323	-0.017	-1.159***	-0.454*	-1.627***	-0.639***
	(0.245)	(0.120)	(0.253)	(0.259)	(0.252)	(0.214)
city	yes	yes	yes	yes	yes	yes
industry	yes	yes	yes	yes	yes	yes
r2_p	0.279	0.155	0.191	0.231	0.132	0.154
Ll	-757.597	-2674.724	-676.632	-551.263	-716.490	-1103.311
N	1933	1940	1207	1203	1208	1903
Panel B: other regions						
SOE	0.191	-0.496***	-1.263***	1.142***	-1.651***	-0.592***
	(0.245)	(0.101)	(0.285)	(0.363)	(0.303)	(0.211)
Foreign	0.461	0.121	0.068	0.172	0.460	0.274
	(0.448)	(0.080)	(0.318)	(0.385)	(0.306)	(0.262)
SIZE	0.193***	0.097***	0.102**	0.092	0.276***	0.203***
	(0.049)	(0.014)	(0.049)	(0.060)	(0.055)	(0.039)
_cons	1.807***	0.476***	-0.238	1.108**	-2.507***	-0.190
	(0.496)	(0.096)	(0.330)	(0.433)	(0.384)	(0.278)
City	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes
r2_p	0.290	0.216	0.104	0.195	0.294	0.109
Ll	-290.008	-1055.665	-252.948	-147.522	-211.493	-478.185
N	784	796	434	434	437	790

Note: Robust standard errors in parentheses. "* p<0.1, ** p<0.05, *** p<0.01" for significance. The base group for ownership is domestic private firm.

Finally, we are interested in the effects of ownership and size on different industries. Firms operating in Chemicals, Electronics, Precision instruments and IT are assigned into the high-tech group, otherwise traditional industry. We find in Table 6 that, compared to the private firms, SOEs show stronger process innovation capacity in high-tech industry than that in traditional industry. However, the disparity between SOEs and private firms in organization innovation and promotion innovation become even larger in high-tech industry group than that of traditional industry group. Interestingly, the comparative advantage of foreign firms in innovation ability mainly exists in traditional industry. Evidence consistently show that the firm size is positively correlated with stronger innovation capacity in both high-tech and traditional industry.

Table 6 Effects of Ownership and Size on Innovation: Different Industries

	innovativeness (1)	*scope* (2)	*product* (3)	*process* (4)	*organization* (5)	*promotion* (6)
Panel A: high-tech industry						
SOE	0.415	-0.461***	-0.936**	2.043**	-1.051**	-1.679***
	(0.701)	(0.175)	(0.432)	(0.795)	(0.491)	(0.414)
Foreign	-0.200	0.067	0.090	-0.231	0.196	0.190
	(0.574)	(0.126)	(0.399)	(0.509)	(0.376)	(0.398)
SIZE	0.433***	0.107***	0.203***	0.418***	0.284***	0.234***
	(0.089)	(0.018)	(0.063)	(0.090)	(0.065)	(0.057)
_cons	-0.606	-0.595***	-1.207	3.181***	-2.725***	0.501
	(0.507)	(0.120)	(0.837)	(0.722)	(0.868)	(0.493)
City	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes
r2_p	0.254	0.171	0.255	0.302	0.213	0.241
Ll	-126.642	-616.647	-147.789	-96.611	-161.901	-201.279
N	322	435	288	222	297	394
Panel B: traditional industry						
SOE	0.131	-0.323***	-1.004***	1.009***	-0.585**	-0.387***
	(0.168)	(0.081)	(0.225)	(0.344)	(0.249)	(0.140)
Foreign	0.369	0.196***	0.276	0.580**	0.434**	0.350**
	(0.257)	(0.050)	(0.208)	(0.232)	(0.199)	(0.162)
SIZE	0.202***	0.116***	0.129***	0.183***	0.231***	0.135***
	(0.027)	(0.010)	(0.029)	(0.035)	(0.031)	(0.022)
_cons	1.367***	0.379***	-0.486**	0.643**	-2.005***	0.062
	(0.263)	(0.077)	(0.233)	(0.315)	(0.256)	(0.193)
city	yes	yes	yes	yes	yes	yes
industry	yes	yes	yes	yes	yes	yes
r2_p	0.280	0.173	0.168	0.206	0.170	0.130
Ll	-905.543	-3093.853	-772.106	-581.358	-769.071	-1350.709
N	2278	2291	1340	1274	1345	2260

Note: Robust standard errors in parentheses. "* p<0.1, ** p<0.05, *** p<0.01" for significance. The base group for ownership is domestic private firm.

5. Conclusion

Enterprise innovation varies in different settings. China is now transforming to an innovation driven economy as she deepens market oriented reforms. In this paper, we examine the effects of ownership and size on enterprise innovation with the Chinese enterprise survey data by the World Bank. We measure enterprise innovation in various ways to get heterogeneity effects of the two variables. Empirical findings show that among the domestic enterprises, the SOEs and private enterprises are not different in innovation participation, but varied in the innovation diversification. SOEs show innovation capability in process innovation, and private enterprises are advantageous in product innovation, organization innovation and promotion innovation. We also find that even for SOEs, the involvement of private investment leads to different performance in innovation. Size of a firm show strong positive effects on innovation. Foreign invested enterprises are still more innovative in many types of innovation excepts product innovation.

Different from previous studies that investigate the separate effects of ownership and size on innovation, we find that there are joint effects of those two features on innovation. Empirical findings show enterprises of different ownerships, for example, SOEs and foreign invested companies have comparative advantages in different innovation types. But these comparative advantages are changeable when taking size into consideration. We also find the innovation effects of ownership and size vary geographically and by industry.

Our findings demonstrate enterprise innovation is rather sophisticated when the joint effects of ownership and size are presented, which undermines the targeting efficiency of innovation policy, no matter it is based on single criterion or a set of criteria. China's innovation policy needs to avoid the path dependence of selective industrial policy, and to transform towards improving the innovation climate, such as securing a level-playing field, strengthening public innovation platforms, and improving the intellectual property protection, etc.

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