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Making of an innovative economy: a study of diversity of Chinese enterprise innovation

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Abstract

Purpose – This research examines the effects of firm ownership and size on innovation capability using data from the World Bank China Enterprise Survey (WBCES), which provides directly measurable innovation-related variables. Key consideration is given to the role and innovation capability of state-owned enterprises (SOEs) compared with domestic and foreign private enterprises in the Chinese economy.

Design/methodology/approach – In its quest for technological self-reliance and a new developmental path, China is focusing on its enterprise innovation capability.

Findings – The findings suggest that SOEs and domestic private enterprises are similar in terms of innovation participation but differ in terms of innovation diversification, which implies ownership-specific innovative advantages. In general, the authors find that SOEs are more innovative with respect to processes innovation but less so with respect to product, management and promotion innovations. Foreign-owned enterprises are superior in all types of innovation except product innovation.

Research limitations/implications – The authors also find that size is an important determinant of innovation capability, with the effect varying depending on location and industry. Moreover, the joint effect of firm ownership and size on innovation declines with increasing size. These findings provide new insights into the evaluation of China's major policies.

Originality/value – This research examines the effects of ownership and size on enterprise innovation capability, using the WBCES (2013) data, which include direct measurable innovation related variables.

Keywords China, Innovation capability, Ownership, Size, SOE, Innovation type

Paper type Research paper

1. Introduction

With the gradual slowing of rapid economic growth, China is shifting towards a new high-quality development model. This comes at a time of accelerating conflicts with the United States on both technological and industrial fronts. Seeking technological self-reliance becomes an important task for China's new development model. Enterprise innovation is considered a key solution to navigating this new development stage. Compared with other

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determinants of enterprise innovation, including market competition, financial support and intellectual property protection (Cohen, 2010), the role of firm ownership in China's socialist market economy, in which state-owned enterprises (SOEs) actively participate alongside private enterprises, is significant. Further, the size of SOEs tend to be large in terms of the number of employees and assets, and several private Chinese companies have grown into world-class giants over a short period. Although the role of firm ownership and size in innovation have been well covered in the literature, the ongoing reforms of SOEs and the rapid development of innovation in China provide ample impetus to study the innovation capability of Chinese enterprises.

Since the mid-1990s, massive SOE reforms have taken place under the principle of "seize the big and free the small" (*zhuada fangxiao*) [1]. While a significant number of small and medium-sized SOEs, mostly those in deregulated industries, have been privatised, large SOEs in selected key sectors have remained under the control of various levels of governmental hierarchies [2]. When China launched its nationwide innovation plan in 2006, SOEs were incentivised to develop an enterprise strategy that highlights innovation strategies. For example, in the first version of performance assessment implemented by the State-owned Assets Supervision and Administration Commission of the State Council (SASAC) [3] in 2004, there were few incentive schemes for senior executives of SOEs who carried out innovation. However, a reward scheme for SOE innovation outcomes was added in a 2007 amendment and emphasised in the 2012 and 2016 amendments. In recent years, some Chinese SOEs in industries such as high-speed railway, nuclear power generation, aerospace, shipbuilding and ultra-high voltage grids have achieved impressive innovations that have rejuvenated their social image. Chinese SOEs actively contribute during the recent COVID-19 pandemic by providing medicines, vaccinations and new test kits, which is also a form of innovation. This renews the debate about whether Chinese SOEs have particular innovative advantages over their private counterparts. Research on SOE innovation performance is contentious. Based on theoretical hypothesis like multiple principle-agents, SOEs are often criticised for being less efficient compared with their private counterparts because of weak incentives. Nevertheless, they are usually well equipped with talent development and research and development (R&D) facilities, favouring innovation.

The Chinese private sector is also receiving attention in terms of its innovation (Brandt and Zhu, 2010). First, since the economic reforms in 1978, an increasing number of foreign companies have invested in China as joint ventures, serving as a source of technological progress and productivity growth (Fu and Gong, 2011; Liu and Buck, 2007). The knowledge and managerial spillovers from foreign companies have benefited domestic enterprises. Second, domestic enterprises have become increasingly active in innovation, especially in deregulated and emerging industrial sectors beyond the reach of SOEs, such as information and telecommunication equipment, smartphones, solar voltaic manufacturing, new energy vehicles and drones.

Recent Chinese industrial policies have deliberated on the relationship between firm size and innovation capability. A government policy aimed at strengthening the state regulation of industrial investments and production has resulted in an increasing number of mergers and acquisitions (M&As) between SOEs, including rail manufacturing, steel, hydropower, nuclear power, mining, chemical, construction material and shipbuilding industries. Advocates of M&As claim that larger enterprises have advantages in innovation because of their ability to mobilise resources, their market power and their manufacturing functions. Large enterprises also enjoy size-based supportive policies. Since the *zhuada fangxiao* adjustment in the 1990s, SOEs are typically large; thus, the policy preference towards state ownership and large firm size is inherently reinforced. Since the 12th Five-Year Plan (2010–2015), a nationwide public service system has been launched to strengthen the innovation capabilities of small businesses and entrepreneurships. Some Chinese start-ups have grown

to be national or even global key players in a short period, demonstrating the spirit of "small is beautiful".

This paper explores various aspects of Chinese firm ownership and size on innovation based on data from the World Bank China Enterprise Survey (WBCES) (World Bank, 2013) rather than conventional indicators, such as R&D expenditure and patents. The WBCES is the most recent available dataset and contains novel and rich information about enterprise innovation practices. Given that the dataset provides direct measurable innovation variables, the results are more robust in determining enterprise innovation capabilities. We incorporate four different types of innovation variables following the *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (Organisation for Economic Co-operation and Development [OECD] and Statistical Office of the European Communities [Eurostat], 2005). Analysing these different innovation types provides a deeper understanding of the innovation behaviours of firms. The findings show that enterprises with different ownership structures have different innovation capabilities. SOEs with mixed ownership focus mainly on process innovation, while foreign enterprises practise almost all types of innovation, except product innovation. With respect to size, larger firms are found to have higher innovation capabilities in most of the specifications. Moreover, we explore the joint effect of ownership and size to investigate the link between these two variables. We find that the innovation effect diminishes as the size of the enterprises increases. This is true for both SOEs and foreign enterprises, indicating that relatively smaller firms are more innovative, regardless of their ownership structure.

The rest of the paper is structured as follows. Section 2 reviews the literature, focusing separately on the role of firm ownership and size on innovation capabilities. Section 3 presents the research methods and description of the data. Section 4 presents the results, discussion and robustness tests, and Section 5 concludes the paper.

2. Literature review

Countries vary in their innovation capabilities due to diversified institutions (Choi *et al.*, 2011). Some studies concentrate on institutional innovation at the macrolevel (Soskice, 1997), including the national, regional and sectoral levels (Cook *et al.*, 1997; Freeman, 1995; Lundvall, 1992; Malerba and Orsenigo, 1997; Nelson, 1993). Others take a microapproach to exploring institutional settings that are most conducive to enterprise innovation, such as information and organisational incentives (Azoulay and Lerner, 2013). The ample research on enterprise innovation and enterprise theory sheds light on the relationships between the influence of firm nature (ownership) and boundary (size) on innovation practices.

2.1 Ownership and innovation

Several studies have illustrated the significance of ownership structure on enterprise innovation (Aghion and Tirole, 1994; Aghion *et al.*, 2013; Cucculelli and Peruzzi, 2020; Dachs and Peters, 2014; Minetti *et al.*, 2015). Moreover, different firm theories have different implications for innovation (Francis and Smith, 1995; Ortega-Argilés *et al.*, 2005). For example, the Grossman–Hart–Moore model suggests that firm ownership strongly influences the firm's *ex ante* investment decisions because the residual claim lies in the hands of the owner (Grossman and Hart, 1986; Hart and Moore, 1990). These decisions may relate to R&D expenditure, thus the innovation capability of the enterprise.

The effect of ownership on enterprise innovation is even more complicated for transition economies such as China, where SOE ownership restructuring has been a key component of reform. Choi *et al.* (2011) study 548 publicly traded Chinese enterprises across eight industries, finding that enterprises with foreign ownership and business group affiliations

are more innovative, insider ownership has a negative effect on innovation performance and ownership concentration has no significant effect on innovation. Jefferson *et al.* (2003) study the innovation capability of 22,000 large and medium-sized Chinese enterprises that underwent ownership diversification during the 1994–1999 SOE reforms, finding an increase in R&D intensity in both input and outputs. Xu and Zhang (2008) investigate 541 publicly traded companies in five high-tech industries during 2000–2005 and conclude that state ownership has a positive effect on process innovation but not product innovation. Guan *et al.* (2009) study 1,244 enterprises in Beijing and find that enterprise size, rather than ownership, explains innovation rate and innovation sales. Lin *et al.* (2011) find that sales-based incentives for CEOs are more conducive to improving corporate innovation effort and performance compared with profit-based incentives. Boeing *et al.* (2016) find that R&D activities have a more positive and sustained effect on total factor productivity of privately owned listed enterprises in China compared with SOEs. Kroll and Kou (2019) find that state ownership inhibits innovation, especially in China's north-eastern regions and mid-tech sectors.

China emerged as one of the prime foreign direct investment (FDI) destination after the reforms it undertook in various aspects, like export promotion, FDI encouragement, tax and tariff ease, loaning facility, exchange rate, etc. (Huang *et al.*, 2017). Given the attraction of China for the FDI, the role of foreign investment in Chinese enterprise innovation has also been scrutinised (Cheung and Lin, 2004; Ito *et al.*, 2012; Lin and Lin, 2010; Liu and Zou, 2008). AlAzzawi (2012) categorised countries as either technology leaders or technology followers, finding that both inward and outward FDIs are important to the innovation capability of technology followers. Hu *et al.* (2005) find that the FDI does not facilitate the adoption of market-mediated foreign technology transfer. Jefferson *et al.* (2003) find no differences in R&D expenditure intensity across various types of ownership for large and medium-sized manufacturing enterprises from 1994 to 1999. Liu and Buck (2007) find that the R&D activities of Chinese high-tech multinational enterprises affect the innovation performance of domestic enterprises through learning-by-exporting (and importing). Girma *et al.* (2008) confirm such a positive effect in export-oriented SOEs with human capital or prior experience in R&D. Zhang *et al.* (2020) find that the ongoing mixed ownership reforms in China have improved the innovation of SOEs as well as private enterprises participating in such reforms.

The ownership structure of Chinese enterprises needs special attention when investigating their innovation capability. This is because of the intertwined role of SOEs and privately owned enterprises in the Chinese economy and society as well as the role of foreign enterprises.

2.2 Enterprise size and innovation

The literature on the effect of firm size on innovation capability largely revolves around Schumpeter's theory of "creative destruction" (Fisher and Temin, 1973; Levin *et al.*, 1985; Schumpeter, 1942). The advantages and disadvantages of enterprise size on innovation have been examined over time (Chandler *et al.*, 1997; Cohen and Klepper, 1996; Cohen and Levin, 1989; Kamien and Schwartz, 1975; Legge, 2000; Shefer and Frenkel, 2005). Some studies have found inconsistent *U*-shaped or inverted U-shaped relationships between enterprise size and innovation (Cohen *et al.*, 1987; Comanor, 1967; Grabowski, 1968; Jaffe, 1988; Kamien and Schwartz, 1982; Kohn and Scott, 1982; Mansfield, 1964; Scherer, 1965, 1980; Soete, 1979). Some have found industry-specific effects on innovation arising from the division of labour between large and small enterprises (Arora *et al.*, 2002; Teece, 1986). Acs and Audretsch (1987, 1988) claim that large enterprises in capital-intensive, concentrated and advertising-intensive industries tend to have innovative advantages, while small enterprises tend to have innovativeness advantages in the early stages of their life cycles.

In the context of Chinese enterprise innovation, Hu (2001) finds that enterprise size is positively related to innovation in 813 high-tech enterprises in Beijing. However, Jefferson *et al.* (2006) find no significant effect of enterprise size on R&D intensity for large and medium-sized enterprises after controlling for industry effects. Yam *et al.* (2004) conclude that different innovation capabilities lead to divergent performance for large, medium-sized and small enterprises in Beijing. Tsai and Wang (2005) use a sample of 126 publicly listed manufacturing enterprises in Taiwan Province of China and find a "*U*-type" relationship between R&D productivity and enterprise size. In general, the influence of the size of Chinese enterprises on their innovation capability is still unclear.

Some studies have investigated the joint effects of firm ownership structure and size on innovation. Love *et al.* (1996) reveal that firm size and non-United Kingdom ownership have a positive effect on the likelihood of innovation. Based on a survey in Jiangsu province in 2003–2004, An *et al.* (2006) show descriptive R&D indicators of different enterprise ownerships and sizes. The joint effect of ownership and size is particularly important in Chinese enterprise innovation. First, as mentioned previously, China's major size-based SOE reform led to the privatisation of most of its smaller SOEs, leaving only larger enterprises as state owned. This has led to a joint effect of state ownership and size on innovation for these SOEs. Second, Chinese innovation support systems, such as funding, national science and innovation projects and prizes for outstanding innovation achievements, are directed more towards domestic and large enterprises, possibly resulting in an upward bias.

3. Research methodology and data

The focus of this study is on the innovation capability of Chinese enterprises from the perspective of ownership structure and size of the enterprises. Ownership is a primary concern given China's strong SOE base and vibrant private sector. Size in terms of the number of employees is also important given that almost all types of enterprises on this front in China show a certain level of innovation capability.

3.1 Data and innovation variables

The dataset used in this study is the most recent WBCES (World Bank, 2013), which took place from December 2011 to February 2013. The WBCES measure the quality of businesses and investment climate, and our sample covered 2,700 private and 148 SOEs from 25 cities [4]. Sample cities were selected based on the number of establishments, their contributions to employment and their value added. The dataset is rich in terms of enterprise-level information such as innovation activities, ownership, size, location and industrial distribution. The WBCES captures innovation strategies of enterprises directly rather than using conventional proxies, such as patents and R&D expenditure [5].

We follow the four types of innovation defined in the *Oslo Manual* (OECD and Eurostat, 2005): product innovation, process innovation, management innovation and promotion innovation. This classification provides a direct and detailed measurement of enterprise innovation behaviours rather than using indirect indicators such as inputs (e.g. R&D expenditure) and outputs (e.g. patent statistics) and is more meaningful in measuring enterprise innovation behaviours and policy implications. The study of Schubert and Tavassoli (2020) reports several studies and surveys that have extensively applied the *Oslo manual* and argues for the reliability, validity and interpretability of such method and data. Such practice has become increasingly popular in the fields of management and economics. The WBCES stands out as one of the best available database that effectively captures these four types of innovation in China. We utilize these data to provide new evidence for an existing theoretical framework.

We define and measure enterprises' innovation efforts and behaviours in the following manner: If an enterprise answers "yes" to the question, "Over the last three years, has this establishment engaged in introducing a new product or new service?", we define this as *product innovation* (equals to 1, otherwise 0). If an enterprise answers "yes" to the question, "Over the last three years, has this establishment engaged in taking measures to reduce production costs?", we define this as *process innovation* (equals to 1, otherwise 0). If an enterprise answers "yes" to the question "Over the last three years, has this establishment engaged in introducing new managerial/administrative processes?" we define this as *management innovation* (equals to 1, otherwise 0). If an enterprise responds with "frequently" or "all the time" (instead of "rarely" or "sometimes") to the question, "To what extent are information and communication technologies (computers, Internet and software) used to support marketing and sales?", we define this as *promotion innovation* (equals to 1, otherwise 0).

3.2 Research design

We further measure enterprise innovative capabilities according to two dimensions: *innovation specialisation* and *innovation diversification*. *Innovation specialisation* includes four innovation variables (product, process, management and promotion), as described above, to indicate the extent of enterprise innovation. We define the variable *innovativeness* as whether an enterprise carries out any of the four innovation types. Hence, in total, *innovation specialisation* includes five aspects: *innovativeness*, *product*, *process*, *management* and *promotion*. All variables are binary dummies and take a value of one if an enterprise is innovative, and 0 otherwise. We use a standard probit model for estimation:

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

where q_i is the probability of an enterprise that accomplished innovation activity i, and i is the dummy for the innovation variables. Enterprise ownership and size are the two explanatory variables of interest. In China, *ownership* may include state, private or foreign ownership. If the state is the major shareholder, the enterprise is labelled an SOE. If a private domestic (or foreign) agent is the major shareholder, the enterprise is labelled as privately owned. We measure enterprise size by its number of permanent full-time workers in natural logarithm form. Given that the dataset mostly provides innovation variables from the past three years, we measure size according to the end of the 2008 fiscal year. X is a set of control variables for individual enterprises along with industry and city fixed effects. $\varnothing$ is the random error term.

For *innovation diversification*, we define a count variable *diversification* by the number of innovation types achieved, with values of 0, 1, 2, 3 or 4. For example, if an enterprise undertook no innovation, it takes a value of 0; if an enterprise achieved one type of innovation, it takes a value 1; if an enterprise achieved two types of innovation, it takes value of 2 and so on. Given the nature of the count data, we use the Poisson estimation approach as follows:

$$\ln \mu_i = d_1 + d_2 * \text{ownership}_i + d_3 * \text{size} + D * X + \varsigma_i, \tag{2}$$

where μ_i is the mean of innovation count y_i ($y_i = 0, 1, 2, 3, 4$), and y_i follows a Poisson distribution (Cameron and Trivedi, 1998). As in Equation (1), X refers to the control variables of individual enterprises and industry and city fixed effects, and ς_i is the random error term.

Based on the previous literature described in Section 2, we include three enterprise-specific variables as controls: age, finance and labour costs. The age of the enterprise is expressed by the difference between the survey year and the official registration year. The finance variable is based on the proportion of working capital financed through internal funds/retained earnings. The larger the value of the variable, the less the external financing.

Labour cost as a natural logarithm is calculated by summing the total annual costs of labour, including wages, salaries, bonuses and social security payments. Moreover, we conduct a robustness test of enterprise size by estimating the total annual sales of all products and services.

Table 1 presents the descriptive statistics of key variables. The sample spans 24 two-digit industries, including plastics and rubber, machinery and equipment and textiles. Nearly 77% of enterprises report achieving at least one type of innovation. On average, the surveyed enterprises report 1.61 types of innovation. Process innovation is the most common type of innovation (75%), followed by promotion innovation (57%), product innovation (53%) and management innovation (47%). Private enterprises accounted for 90% of all enterprises, followed by SOEs (7%) and foreign enterprises (3%).

4. Empirical results

We run estimations based on Equations (1) and (2). While our baseline estimation caters to the primary research outcome of the effects of ownership and size on the innovation capability of Chinese enterprises, we also conduct estimations of other attributes. For instance, we distinguish between pure and mixed SOE ownership by using information on the state share of these SOEs. Also, we divide firms into those located in China's eastern region and those located in the rest of China to explore the significance of China's Eastern Belt. Finally, we consider the industry perspective, categorising the sample into high-tech and traditional industries. Analysing the effects of heterogeneity not only helps to cement the findings of our baseline model but also facilitates a more in-depth understanding of the subject matter.

4.1 Baseline model

Table 2 reports the baseline estimation results from Equation (1). Column 1 (*innovativeness*) shows that after controlling for city and industry fixed effects, the estimated coefficient for SOE is insignificant, [6] indicating that there is no difference between domestic private enterprises and SOEs in terms of innovativeness. This finding is likely to reflect the outcomes of China's SOE reforms. Since 2000, when SOEs were urged to adopt a more modern enterprise system, most SOEs have developed a modern governance structure through the establishment of boards of shareholders, directors, supervisors and managers [7]. Publicly listed SOEs, in particular, are responsible for the interests of public investors and subject to

Variable	*N*	Mean	SD	Min	Max
Innovativeness	2,817	0.77	0.42	0	1
Diversification	2,817	1.61	1.38	0	4
Product	1,695	0.53	0.50	0	1
Process	1,697	0.75	0.43	0	1
Management	1,699	0.47	0.50	0	1
Promotion	2,774	0.57	0.50	0	1
Foreign	2,817	0.03	0.18	0	1
SOE	2,817	0.07	0.26	0	1
Size	2,738	229.01	1,439.39	0	50,000
Age	2,737	13.07	8.75	0	133
Finance	2,764	89.21	20.22	0	100
Labour cost	2,768	1,240.00	16,600.00	0.002	840,000

Note(s): City and industry variables are not listed
SOE: state-owned enterprise

Table 1.
Descriptive statistics of key variables

Table 2. Effects of ownership and size on innovation

Variable	(1) Innovativeness	(2) Diversification	(3) Product	(4) Process	(5) Management	(6) Promotion
SOE	0.192 (0.170)	−0.345*** (0.072)	−0.956*** (0.214)	1.208*** (0.331)	−0.702*** (0.236)	−0.486*** (0.135)
Foreign	0.191 (0.233)	0.168*** (0.049)	0.198 (0.184)	0.348* (0.203)	0.365** (0.182)	0.308** (0.153)
Size	0.158*** (0.050)	0.055*** (0.019)	−0.089* (0.052)	0.103 (0.063)	0.110** (0.053)	0.060 (0.041)
Age	−0.002 (0.004)	0.001 (0.001)	−0.001 (0.004)	0.003 (0.005)	0.005 (0.004)	0.000 (0.003)
Finance	−0.005*** (0.002)	−0.002** (0.001)	−0.005** (0.002)	−0.007*** (0.002)	−0.003 (0.002)	−0.001 (0.002)
Labour cost	0.072* (0.044)	0.065*** (0.018)	0.244*** (0.049)	0.103* (0.058)	0.138*** (0.049)	0.111*** (0.037)
Constant	1.014* (0.541)	−0.118 (0.222)	−2.482*** (0.630)	0.233 (0.711)	−3.354*** (0.643)	−1.045** (0.465)
City fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.284	0.175	0.186	0.245	0.180	0.142
Log likelihood	−994.8	−3514.4	−874.6	−660.3	−884.7	−1497.9
N	2,571	2,583	1,553	1,558	1,564	2,550

Note(s): The base ownership group is domestic private enterprises
Robust standard errors are in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$ and $^{***}p < 0.01$

supervision bodies. Consequently, enterprises with different ownership structures converge in terms of governance and operations. Another possible explanation is that China's industrial decentralisation reforms have led to market competition playing an increasingly important role in deregulated industries, driving enterprises to seek competitiveness through innovation, regardless of ownership. Further, incentive schemes that encourage SOEs to carry out innovation are inclined to boost innovation participation.

Column 2 shows the *diversification* aspect of innovation based on Equation (2). The negative significant coefficient for SOE indicates that SOEs are less likely to engage in diverse innovation types. This result is further confirmed by the remaining columns. Compared with domestic private enterprises, SOEs have stronger process innovation capabilities (Column 4) but weaker product innovation (Column 3), management innovation (Column 5) and promotion innovation (Column 6) capabilities. There are some possible explanations for this. First, process innovation is less risky compared with product innovation, which aligns with SOEs' preference for risk aversion. Second, inflexible employment terms and strong supervision may mean that SOEs are less active in managerial innovation. Third, given that a number of SOEs are monopolies with sole access to strategic resources, some managers may perceive that promotion innovation is not required.

With respect to foreign enterprises, the coefficient for *innovativeness* is not significant, indicating that foreign enterprises are not significantly different from domestic private enterprises in terms of overall innovativeness. However, they are significant in terms of innovation diversification, engaging in all types of innovations except product innovation. This reinforces our conviction that the FDI in China is likely to contribute to technology and management spill-overs [8].

With respect to the effect of *size*, coefficients are highly significant for *innovativeness* and *diversification*. This provides evidence that larger enterprises enjoy stronger innovativeness and diversification benefits. Nevertheless, the results are varied for the four specific innovations. Enterprise size is positively correlated to management, promotion and process innovation types but is only significant for management innovation, implying that this explains most of the innovativeness of enterprises. In contrast, product innovation is negative and significant at the 10% level. This indicates that larger enterprises, which may control the market with pre-existing products, may not be interested in innovating new products; rather, it is small and medium-sized enterprises that continually need to innovate new products in the face of intense competition.

With respect to other enterprise-specific control variables, we find that both finance and labour costs are significant at various levels, depending on the specification. The coefficients for finance are all negative, indicating that enterprises with internal finance tend to be less innovative, whereas the coefficients for labour costs are all positive, indicating that enterprises tend to reward employees who are innovative.

4.2 Analysis of heterogeneity effects

We further examine the effects of four different types of firm ownership and size on innovation: pure and mixed state ownership, joint effects of ownership and size, regional differences and industrial distribution.

First, reforms towards mixed ownership were introduced in the 1990s. To investigate whether this reform has changed the innovation behaviours of SOEs, we further divide the SOE dummy into two dummies: pure SOEs (*psoe*) with a state ownership share of 100% [9] and SOEs with mixed ownership (*mosoe*), in which the state is still the major shareholder, but private shareholders are also present. The results (see Table 3) show that mixed ownership undermines almost all types of innovation, except process innovation, compared with private enterprises. This result suggests that the restructuring of enterprises towards mixed

Table 3.
Effects of ownership and size on innovation: pure and mixed-ownership SOE

Variable	(1) Innovativeness	(2) Diversification	(3) Product	(4) Process	(5) Management	(6) Promotion
Mosoe	0.337 (0.222)	−0.377*** (0.074)	−0.993*** (0.222)	0.163*** (0.031)	−0.824*** (0.248)	−0.647*** (0.156)
psoe	−0.079 (0.281)	−0.205 (0.229)	−0.583 (0.660)	−0.090 (0.192)	0.219 (0.745)	0.049 (0.278)
Foreign	0.188 (0.232)	0.168*** (0.049)	0.196 (0.184)	0.077* (0.042)	0.377** (0.178)	0.310** (0.152)
Size	0.157*** (0.050)	0.056*** (0.019)	−0.088* (0.052)	0.028** (0.013)	0.112** (0.053)	0.060 (0.041)
Age	−0.001 (0.004)	0.001 (0.001)	−0.001 (0.004)	0.001 (0.001)	0.004 (0.004)	−0.000 (0.003)
Finance	−0.005*** (0.002)	−0.002** (0.001)	−0.005** (0.002)	−0.002*** (0.001)	−0.003 (0.002)	−0.001 (0.002)
Labour cost	0.074* (0.044)	0.065*** (0.018)	0.244*** (0.049)	0.017 (0.012)	0.137*** (0.049)	0.111*** (0.037)
Constant	0.966* (0.544)	−0.116 (0.221)	−2.474*** (0.631)	0.712*** (0.151)	−3.336*** (0.644)	−1.021** (0.465)
City fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.285	0.175	0.187	0.255	0.182	0.143
Log likelihood	−994.060	−3,514.125	−874.422	–	−883.392	−1,495.648
N	2,571	2,583	1,553	1,567	1,564	2,550

Note(s): The base ownership group is domestic private enterprises
mosoe: state-owned enterprises with mixed ownership
psoe: pure state-owned enterprises
For the process innovation regression, ordinary least squares estimation is reported because the coefficient of *mosoe* is omitted in the probit estimation
Robust standard errors are in parentheses
*$p < 0.1$, **$p < 0.05$ and ***$p < 0.01$

ownership was mainly oriented towards cost reduction. Process innovation is positive and significant for mixed ownership but negative (and insignificant) for pure SOEs, indicating that the improved performance of SOEs in terms of process innovation (shown in Table 2) is mainly based on the contributions of those with mixed ownership. Given that process innovation is defined as a reduction in production costs, these results imply that state–private partnerships are mainly driven by cost-saving considerations. The results for size are similar to those of the baseline model, being highly significant for innovativeness and diversification, albeit divergent for specific innovations. The estimations for foreign ownership, age, finance and labour costs are consistent with Table 2.

Second, we examine the joint effects of ownership and size. Following the strategic adjustments to SOEs in the 1990s, small SOEs became privatised, while large SOEs remained tied to the state. Given that SOEs in China are generally larger than privately owned enterprises, there may be a joint effect of ownership and size on innovation. We use the interaction term of ownership and size to estimate the joint effect (see Table 4). The results show that SOEs are stronger in terms of process innovation (Column 4), but this effect diminishes as enterprise size increases, as indicated by the interaction term. There are two possible explanations for this. First, larger SOEs are likely to enjoy favourable size-based support such as cheap finance, energy and land supply. Second, larger SOEs may have increased market power and be unaffected by price competition; thus, process innovation is not as essential. The results also show that compared with domestic private enterprises, foreign enterprises have stronger innovation diversification as well as better process, management and promotion innovation. However, as firm size increases, these advantages weaken. The size variable produces similar results as those of the baseline model.

Third, we examine whether the effects of firm ownership and size on innovation differ according to regions. Given that the eastern region of China is more economically developed and market friendly, the business sector there plays a leading role in promoting innovation. We categorise enterprises into two groups based on their location: "eastern region" and "other regions". The estimation results (see Table 5) show that within the regions, the results are consistent with our previous results in terms of ownership and size. While comparing between the regions, the difference between private enterprises and SOEs in terms of their innovation capability is less in the eastern region, especially for management innovation, compared with enterprises located elsewhere. Foreign enterprises located in the eastern region also tend to be more innovative than those in other parts of China. Nevertheless, these observations are plausible since the difference between the coefficients is mostly not statistically significant. With respect to enterprise size, the results for enterprises in the eastern region are analogous to those of the baseline model, with innovativeness and diversification being significant but management innovation being insignificant. For other regions, the effect of enterprise size is somewhat inconclusive, being significant only for diversification and management innovation. This indicates that size matters mainly in the relatively developed area of the Eastern Belt.

Finally, we examine the effects of firm ownership and size on innovation for different industries. Enterprise innovation varies across industries with different technological features. This is particularly important in the case of China, which has continually engaged in decades of industrial upgrading. Consequently, China has been successful in upgrading its product range by diversifying its production capabilities (Chen *et al.*, 2020). For instance, during the 1970 and 1980s, China mainly produced natural resources and agricultural products. However, by the 1990 and 2000s, China was producing and exporting low-tech, labour-intensive products, such as toys and footwear along with textiles. This was further expanded to electrical/electronic items and machinery in the late 2010s. We categorise enterprises in the chemical, electronics, precision instruments and information technology industries as "high-tech industries" and the remainder as "traditional industries". The results

Table 4. Effects of ownership and size on innovation: joint effects

	(1) Innovativeness	(2) Diversification	(3) Product	(4) Process	(5) Management	(6) Promotion
SOE*Size	−0.084 (0.072)	0.035 (0.035)	−0.038 (0.091)	−0.536*** (0.107)	−0.055 (0.104)	−0.065 (0.061)
SOE	0.525 (0.344)	−0.527*** (0.184)	−0.758 (0.487)	3.911*** (0.676)	−0.482 (0.579)	−0.216 (0.301)
Foreign*Size	−0.219 (0.171)	−0.110*** (0.038)	0.181 (0.189)	−0.246 (0.175)	−0.446*** (0.158)	−0.289** (0.122)
Foreign	1.132 (0.809)	0.670*** (0.175)	−0.586 (0.856)	1.430* (0.840)	2.370*** (0.729)	1.577*** (0.568)
Size	0.173*** (0.051)	0.055*** (0.019)	−0.089* (0.053)	0.119* (0.063)	0.124** (0.054)	0.075* (0.042)
Age	−0.001 (0.004)	0.000 (0.001)	−0.000 (0.004)	0.004 (0.005)	0.004 (0.004)	0.000 (0.003)
Finance	−0.005*** (0.002)	−0.002** (0.001)	−0.005** (0.002)	−0.007*** (0.002)	−0.003 (0.002)	−0.001 (0.002)
Labour cost	0.073* (0.044)	0.066*** (0.018)	0.243*** (0.049)	0.117** (0.057)	0.148*** (0.049)	0.113*** (0.037)
Constant	0.938* (0.543)	−0.126(0.220)	−2.469*** (0.628)	−0.051 (0.710)	−3.565*** (0.638)	−1.133** (0.467)
City fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.285	0.176	0.187	0.252	0.185	0.143
Log likelihood	−993.385	−3,512.366	−873.980	−654.470	−879.535	−1,494.872
N	2,571	2,583	1,553	1,558	1,564	2,550

Note(s): The base ownership group is domestic private enterprises
SOE: state-owned enterprise
Robust standard errors are in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$ and $^{***}p < 0.01$

Table 5.
Effects of ownership and size on innovation: different regions

Variable	(1) Innovativeness	(2) Diversification	(3) Product	(4) Process	(5) Management	(6) Promotion
Panel A: Eastern region						
SOE	0.080 (0.244)	−0.277*** (0.102)	−0.908*** (0.314)	1.021* (0.573)	−0.148 (0.306)	−0.442** (0.178)
Foreign	0.091 (0.267)	0.174*** (0.062)	0.200 (0.225)	0.358 (0.242)	0.300 (0.222)	0.337* (0.191)
Size	0.170*** (0.063)	0.051** (0.022)	−0.140** (0.061)	0.108 (0.073)	0.085 (0.059)	0.049 (0.049)
Age	0.006 (0.006)	0.002 (0.002)	−0.006 (0.006)	0.004 (0.007)	0.007 (0.006)	0.006 (0.005)
Finance	−0.008*** (0.002)	−0.003*** (0.001)	−0.008*** (0.002)	−0.007*** (0.003)	−0.007*** (0.002)	−0.003 (0.002)
Labour cost	0.072 (0.055)	0.082*** (0.020)	0.344*** (0.059)	0.136** (0.068)	0.171*** (0.056)	0.107** (0.045)
Constant	−0.728 (0.654)	−0.649** (0.275)	−4.229*** (0.759)	−1.504* (0.819)	−2.936*** (0.718)	−1.708*** (0.559)
R^2	0.297	0.161	0.216	0.246	0.148	0.164
Log likelihood	−701.346	−2491.894	−612.071	−513.473	−659.365	−1026.630
N	1817	1823	1128	1134	1136	1791
Panel B: Other regions						
SOE	0.362 (0.238)	−0.458*** (0.102)	−1.236*** (0.298)	1.568*** (0.382)	−1.677*** (0.324)	−0.514** (0.213)
Foreign	0.363 (0.461)	0.103 (0.080)	0.015 (0.325)	0.124 (0.387)	0.352 (0.316)	0.177 (0.263)
Size	0.108 (0.080)	0.081** (0.037)	0.061 (0.113)	0.055 (0.129)	0.270** (0.127)	0.080 (0.076)
Age	−0.010** (0.005)	−0.001 (0.002)	0.004 (0.006)	−0.000 (0.007)	0.004 (0.006)	−0.008* (0.005)
Finance	0.003 (0.004)	0.003** (0.001)	0.005 (0.004)	−0.005 (0.005)	0.009* (0.005)	0.005 (0.003)
Labour cost	0.095 (0.071)	0.019 (0.033)	0.040 (0.098)	0.039 (0.113)	0.006 (0.106)	0.139** (0.068)
Constant	0.664 (1.023)	0.019 (0.385)	−1.107 (1.161)	1.199 (1.369)	−3.411*** (1.223)	−1.980** (0.831)
R^2	0.302	0.217	0.110	0.200	0.306	0.114
Log likelihood	−272.159	−1006.328	−241.134	−137.082	−198.361	−454.136
N	749	760	415	414	417	754

Note(s): The base ownership group is domestic private enterprises
SOE: state-owned enterprise
All specifications are controlled for industry and city fixed effects
Robust standard errors are in parentheses
*$p < 0.1$, **$p < 0.05$ and ***$p < 0.01$

(see Table 6) indicate that SOEs continue to perform better in terms of process innovation compared with private enterprises in both types of industries, and foreign enterprises are clearly more innovative in traditional industries. Comparing between the industries, we observe that this performance is higher in traditional industries than in high-tech industries. Interestingly, the innovation advantage of foreign enterprises is limited in traditional industries than high-tech industries. Again, these observations are plausible since the difference is usually not statistically significant.

The coefficients for size become nearly insignificant for high-tech industries. This may be because most of the so-called high-tech enterprises specifically related to information technologies are small and medium-sized start-ups. At the time of the survey, these enterprises, although innovative, were still small. The results show that enterprise innovation is more sensitive to size in traditional industries, where most forms of innovations, except product innovation, are significant and positive.

4.3 Robustness analysis

We conduct two different robustness tests for two specific issues. First, we took advantage of the availability of rich size-related variables in the dataset to replace our original size variable (number of permanent full-time workers) with annual sales of all products and services, which is a widely used proxy for enterprise size. The results (see Table 7) are similar to those of our baseline model, confirming our main results.

Second, the proportion of private enterprises in the sample was approximately 90%, meaning that the sample was unbalanced, potentially affecting the results. Therefore, we use propensity score matching (PSM) to balance the observable dimensions of enterprises with different ownership structures to alleviate the effect of the unbalanced sample on the estimations. We take SOEs and private enterprises as examples and construct ownership dummies, with SOEs taking a value of 1 and private enterprises taking a value of 0. The ownership variable is the treated variable, while the other variables (size, age, finance and labour cost) are the matching variables. We find no significant difference between SOEs and private enterprises in the dimensions of matching variables. The results of matching are provided in Appendix Table A1.

Based on the PSM results, we re-examine the effect of firm ownership and size on innovation output. The results shown in Table 8 are highly similar to our main analysis in the previous section. Panel A shows that SOEs are still not statistically different from private enterprises in terms of innovativeness. However, the coefficient for diversification is negative and highly significant, indicating that SOEs are less likely to engage in innovation diversification. With respect to other forms of innovations, the results are similar to those of our baseline model. Panel B reports the results for domestic versus foreign private enterprises. Again, we find that foreign enterprises are more innovative than their domestic counterparts in all forms of innovation activities, including level of innovativeness. The results of these robustness tests further strengthen our main results.

5. Conclusion

China is focusing more on technological self-reliance and, as market-oriented reforms are further intensified, is restructuring its market towards an innovation-driven economy. While the market economy is playing an increasingly important role in coordinating enterprise operations, building innovation capability is now the primary target of China's industrial upgrading. This initiation is geared towards both SOEs and the private sector. In this paper, we examine various effects of enterprise ownership and size on innovation behaviours using the WBCES, which includes more than 2,800 sample enterprises. The key advantage of this database is that it provides direct measurable enterprise-level innovation variables rather

Table 6.
Effects of ownership and size on innovation: different industries

Variable	(1) Innovativeness	(2) Diversification	(3) Product	(4) Process	(5) Management	(6) Promotion
Panel A: High-tech industries						
SOE	0.141 (0.086)	−0.341** (0.146)	−0.736* (0.433)	0.302*** (0.116)	−0.855* (0.471)	−1.613*** (0.416)
Foreign	−0.066 (0.113)	−0.015 (0.139)	−0.167 (0.395)	−0.068 (0.125)	0.020 (0.414)	0.429 (0.425)
Size	0.038* (0.022)	0.044 (0.041)	0.119 (0.115)	0.018 (0.029)	0.029 (0.119)	0.081 (0.114)
Age	−0.004** (0.002)	−0.005 (0.003)	−0.021* (0.012)	−0.001 (0.002)	−0.006 (0.010)	−0.005 (0.011)
Finance	−0.003*** (0.001)	−0.003 (0.002)	−0.019*** (0.007)	−0.000 (0.001)	0.002 (0.005)	0.003 (0.005)
Labour cost	0.022 (0.021)	0.071* (0.041)	0.110 (0.110)	0.041 (0.029)	0.305*** (0.117)	0.227** (0.112)
Constant	0.782*** (0.280)	−1.041** (0.529)	−0.370 (1.686)	0.072 (0.406)	−6.187*** (1.696)	−2.432 (1.510)
R^2	0.291	0.174	0.292	0.353	0.229	0.267
Log likelihood	–	−576.974	−132.963	–	−149.578	−183.866
N	409	409	272	282	280	372
Panel B: Traditional industries						
SOE	0.152 (0.174)	−0.340*** (0.080)	−1.028*** (0.246)	1.031*** (0.368)	−0.632** (0.265)	−0.386*** (0.143)
Foreign	0.305 (0.260)	0.200*** (0.051)	0.263 (0.214)	0.537** (0.234)	0.476** (0.207)	0.310* (0.167)
Size	0.145*** (0.052)	0.058*** (0.022)	−0.141** (0.059)	0.123* (0.071)	0.123** (0.060)	0.054 (0.043)
Age	0.001 (0.004)	0.002 (0.002)	0.004 (0.004)	0.005 (0.006)	0.007 (0.005)	0.002 (0.003)
Finance	−0.004** (0.002)	−0.002* (0.001)	−0.003 (0.002)	−0.008*** (0.003)	−0.004 (0.002)	−0.001 (0.002)
Labour cost	0.060 (0.046)	0.062*** (0.020)	0.282*** (0.056)	0.065 (0.063)	0.115** (0.055)	0.096** (0.039)
Constant	1.121** (0.565)	−0.129 (0.244)	−3.169*** (0.702)	0.663 (0.766)	−3.010*** (0.700)	−0.838* (0.488)
R^2	0.288	0.176	0.184	0.217	0.184	0.134
Log likelihood	−853.785	−2,924.932	−719.135	−550.782	−719.378	−1,277.235
N	2,162	2,174	1,272	1,214	1,282	2,147

Note(s): The base ownership group is domestic private enterprises
SOE: state-owned enterprise
Ordinary least squares regression is reported for *innovativeness* and *process* in Panel A because the coefficient of SOE is omitted from the probit estimation
All specifications are controlled for industry and city fixed effects
Robust standard errors are in parentheses
*$p < 0.1$, **$p < 0.05$ and ***$p < 0.01$

Table 7. Robustness test: size as sales value

Variable	(1) Innovativeness	(2) Diversification	(3) Product	(4) Process	(5) Management	(6) Promotion
SOE	0.228 (0.169)	−0.347*** (0.072)	−1.008*** (0.212)	1.277*** (0.328)	−0.744*** (0.240)	−0.490*** (0.135)
Foreign	0.137 (0.221)	0.136*** (0.049)	0.201 (0.181)	0.387* (0.203)	0.346* (0.181)	0.271* (0.152)
Size	0.106*** (0.037)	0.033** (0.013)	0.053 (0.042)	−0.053 (0.044)	0.096** (0.041)	0.089*** (0.029)
Age	−0.001 (0.004)	0.001 (0.001)	−0.002 (0.004)	0.004 (0.005)	0.005 (0.004)	0.001 (0.003)
Finance	−0.005*** (0.002)	−0.002** (0.001)	−0.003 (0.002)	−0.006*** (0.002)	−0.002 (0.002)	−0.001 (0.002)
Labour cost	0.098** (0.040)	0.078*** (0.016)	0.133*** (0.047)	0.229*** (0.053)	0.137*** (0.047)	0.078** (0.033)
Constant	−0.367 (0.472)	−0.604*** (0.168)	−2.133*** (0.501)	−0.369 (0.574)	−4.426*** (0.524)	−1.700*** (0.385)
R^2	0.289	0.176	0.186	0.243	0.180	0.148
Log likelihood	−10,16.115	−3,601.063	−899.690	−679.044	−906.412	−1,523.606
N	2,636	2,649	1,597	1,595	1,601	2,612

Note(s): The base ownership group is domestic private enterprises
SOE: state-owned enterprise
All specifications controlled for industry and city fixed effects
Robust standard errors are in parentheses
* $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$

Table 8.
Robustness test: results with propensity score matching weights

Variable	(1) Innovativeness	(2) Diversification	(3) Product	(4) Process	(5) Management	(6) Promotion
Panel A: Private versus state-owned enterprises						
SOE	0.275 (0.188)	−0.343*** (0.083)	−0.776*** (0.228)	1.918*** (0.265)	−0.487** (0.244)	−0.580*** (0.153)
Size	0.153** (0.075)	0.088*** (0.033)	−0.045 (0.074)	−0.052 (0.083)	0.072 (0.084)	0.019 (0.063)
Age	−0.001 (0.005)	0.001 (0.002)	0.003 (0.004)	0.003 (0.006)	0.005 (0.004)	−0.003 (0.004)
Finance	−0.001 (0.004)	−0.001 (0.001)	−0.006 (0.004)	−0.006* (0.003)	−0.008** (0.003)	−0.005 (0.003)
Labour cost	0.097 (0.062)	0.046 (0.030)	0.163** (0.070)	0.180** (0.079)	0.113 (0.084)	0.173*** (0.058)
Constant	0.550 (0.831)	0.033 (0.382)	−1.210 (0.973)	−0.445 (0.994)	−2.089** (1.057)	−1.265 (0.798)
R^2	0.339		0.300	0.327	0.312	0.227
Log likelihood	−142.959	−503.678	−99.155	−63.393	−96.508	−203.839
N	2,488	2,499	1,484	1,486	1,492	2,466
Panel B: Private domestic versus foreign enterprises						
Foreign	0.383** (0.183)	0.188*** (0.036)	0.275* (0.167)	0.668*** (0.171)	0.637*** (0.152)	0.521*** (0.140)
Size	−0.071 (0.094)	0.013 (0.031)	−0.040 (0.126)	0.071 (0.125)	0.213** (0.098)	−0.147* (0.078)
Age	0.017 (0.010)	0.007*** (0.003)	0.015 (0.010)	0.050*** (0.013)	0.002 (0.011)	0.027*** (0.009)
Finance	−0.004 (0.004)	0.000 (0.001)	−0.008** (0.004)	−0.004 (0.005)	−0.001 (0.005)	0.007*** (0.003)
Labour cost	0.178** (0.075)	0.057** (0.027)	0.246** (0.115)	0.045 (0.107)	−0.000 (0.093)	0.219*** (0.069)
Constant	0.510 (0.937)	−0.184 (0.338)	−2.956** (1.439)	0.837 (1.275)	−3.183** (1.293)	−2.729*** (0.880)
R^2	0.364		0.270	0.343	0.304	0.265
Log likelihood	−45.237	−234.593	−57.336	−38.635	−57.680	−79.037
N	2,379	2,389	1,469	1,474	1,480	2,359

Note(s): The base ownership group is domestic private enterprises
SOE: state-owned enterprise
All specifications controlled for industry and city fixed effects
Robust standard errors are in parentheses
*$p < 0.1$, **$p < 0.05$ and ***$p < 0.01$

than traditional proxies, such as R&D expenditure and number of patents. We measure enterprise innovation in terms of two dimensions: innovation specialisation and innovation diversification. This is based on the Oslo Manual (OECD and Eurostat, 2005), which categorises innovation into four dimensions: product innovation, process innovation, management innovation and promotion innovation. We also identify the joint effect of enterprise ownership and size on innovation capability. Innovation specialisation is estimated using a standard probit model, with the dependent variable being the enterprise's innovation capability. Innovation diversification is based on the Poisson estimation approach, in which the dependent variables are different types of innovation based on count data.

The empirical results suggest that while SOEs are stronger in the area of process innovation, the private sector possesses a wider range of innovation capabilities in general. Among the three different ownership types investigated, foreign private enterprises are the most innovative in almost all aspects except for product innovation. Domestic private enterprises have better performance in terms of product innovation, management innovation and promotion innovation. In terms of size, the evidence suggests that larger enterprises have higher innovation capabilities. We also find that the process innovativeness of SOEs is largely attributable to the involvement of private investors. This is because pure SOEs (100% state owned) are less effective than those with mixed ownership (in which state has a major share but partners with private investors). The effects of ownership on innovation are significantly affected by enterprise size because the joint effects of ownership and size are found to be statistically significant.

These findings provide new insights for China in terms of formulating policies that facilitate enterprise innovation. First, they support the Chinese government's mixed ownership strategy, implemented in 2013, which have encouraged SOEs to engage in state–private partnerships to enhance competitiveness and innovativeness and develop world-class enterprises. Mixed ownership reduces the cost of process innovation, contributing somewhat to the competitiveness and innovativeness of SOEs. Therefore, mixed ownership reforms may help break through the bottleneck in SOE innovation efforts. Second, given the fact that foreign enterprises continue to outperform Chinese enterprises in all aspects of innovation, China should further open its investment opportunities, particularly in high-tech industries. Third, encouragement of product innovation for both SOEs and the private sector is vital, particularly if China seeks to be self-reliant in terms of key industrial components. Therefore, performance assessment systems and incentive packages for SOEs should focus more on product innovation in the future. One of the limitations of this study is relatively old nature of WBCES data, which is that of year 2013; nevertheless, the latest available such survey data. Several industrial policy changes have been undertaken by the Chinese government since then that are targeted towards innovation capability of enterprises. As a result, notable innovations were observed in most recent years, both in the front of SOE and private enterprises. Nonetheless, the results of this study still shed lights on important role played by size and ownership structure in the context of Chinese economy. In particular, we highlight the variables that could directly measure innovation of firms with the available data. These results are even more significant given the transformation China is making from more of quantity- to quality-based economy.

In summary, our findings demonstrate that enterprise innovation is sophisticated and needs careful consideration in terms of policy formulation, whether it is based on a single criterion or a set of criteria. China's innovation policies need to avoid the path of selective industrial policies and aim to improve the innovation climate, such as securing a level playing field, strengthening public innovation platforms, promoting enterprise-focused innovation (Zeng, 2015; Zhang *et al.*, 2009) and improving intellectual property protections.

Notes

1. The first wave of "seize the big and free the small" with respect to SOEs occurred in 1995. This reform was reinforced in 2003, which established a policy target to develop large, internationally competitive SEOs and conglomerates.
2. Chinese SOEs are affiliated to different levels of government according to the source of state shares. For example, SOEs affiliated with the central government are termed central SOEs. Similarly, there are provincial SOEs, provincial SOEs, municipal SOEs, etc.
3. Founded in 2003, SASAC is a ministerial department of the State Council of the People's Republic of China. As the central government representative of state-owned assets, the SASAC's major obligations are to supervise and administer top management, governance structure, assets and operations of key SOEs. The SASAC's policies and regulations often act as guidelines for subnational governments.
4. Beijing, Chengdu, Dalian, Dongguan, Foshan, Guangzhou, Hangzhou, Hefei, Jinan, Luoyang, Nanjing, Nantong, Ningbo, Qingdao, Shanghai (municipality), Shenyang, Shenzhen, Shijiazhuang, Suzhou, Tangshan, Wenzhou, Wuhan, Wuxi, Yantai and Zhengzhou.
5. Sample questionnaire and other details are available at: https://microdata.worldbank.org/index.php/catalog/1559
6. Note that the coefficients of SOEs and foreign private enterprises are compared with domestic private enterprises, which is the base group in this study.
7. Data are from a 2013 paper by the Ministry of Industry and Information Technology.
8. We conduct an inter-group difference test and find that the coefficients between the two groups are statistically significant. The results are available on request.
9. SOEs in industries listed as crucial to national welfare and people's livelihoods are generally pure SOEs.

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Appendix

Variable	Unmatched/matched	Mean treated	Mean control	*t*	$p>\|t\|$
Panel A: Balance test for private and state-owned enterprises					
Size	U	4.4788	3.9465	5.11	0
	M	4.4494	4.362	0.53	0.596
Age	U	18.33	12.775	8.6	0
	M	17.953	17.175	0.47	0.638
Finance	U	93.247	89.025	2.84	0.005
	M	93.212	92.344	0.51	0.609
Labour cost	U	15.029	14.545	4.29	0
	M	15.018	14.958	0.33	0.74
Panel B: Balance test for private domestic and foreign enterprises					
Size	U	4.4387	3.9465	3.23	0.001
	M	4.4387	4.0996	1.65	0.101
Age	U	11.232	12.775	−1.86	0.063
	M	11.232	12.152	−1.08	0.283
Finance	U	85.122	89.025	−1.71	0.087
	M	85.122	87.936	−0.77	0.444
Labour cost	U	15.123	14.545	3.5	0
	M	15.123	14.725	1.71	0.089

Table A1.

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