Does mixed-ownership reform improve SOEs' innovation? Evidence from state ownership

Xiaoqian Zhang\textsuperscript{a,⁎}, Mingqiang Yu\textsuperscript{b}, Gaoquan Chen\textsuperscript{c}

\textsuperscript{a} Center for Research of Private Economy, School of Economics, Zhejiang University, Hangzhou, China
\textsuperscript{b} AEGON-INDUSTRIAL Fund Management Co., Ltd., Shanghai, China
\textsuperscript{c} Department of International Business, Bank of Ningbo, Ningbo, China

ARTICLE INFO

Keywords:
Innovation
Propensity score matching
Difference-in-differences approach
China reform

JEL classification:
K23
G15
G32

ABSTRACT

This paper investigates the impact of the ongoing mixed-ownership reform on the innovation activities of SOEs in China. We find that the reform improves SOE’s innovation, and the impact is heterogeneous, by exploring in different industries and different regions with the influence of macroeconomic environment. This effect is stronger for SOEs in monopoly industries and eastern developed region. As a new form of state-sector reform, this mixed-ownership reform happens not only in SOEs like previous privatization, but also in a reverse direction. We also find its positive impact of improving the innovation for POEs being mix-reformed. To deal with endogeneity concerns, PSM, DiD and IV estimations are used. We also introduce highway as an instrumental variable, All the results in the 2SLS estimations are robust. Additional tests help isolate the effect of intervention from explanations of macro-economic effects, including house price, private employees, credit and equity finance.

1. Introduction

SOEs are always been considered to be less efficient, both in productivity and innovation. SOE’s productivity is a quarter lower on average than non-SOEs when controlling for the sector, according to IMF’s report (2017). SOEs are more likely to do nothing and to maintain the existing advantages due to agency problems (D’Souza & Nash, 2017), policy burdens and soft-budget constraints (Lin & Tan, 1999; Megginson, Ullah, & Wei, 2014). Managers in SOEs lack professional management skills because they are often appointed by administration (Gan, Guo, & Xu, 2018). In addition, policy burden is one major reason why SOEs do not have sufficient autonomy and flexibility (Xu, 2011). Although China’s State-sector Reform has begun since 1978, it is considered a top priority of the government now which is a new addition to privatization programs over the past three decades (Megginson, 2017). As IMF’s report (2017) concerned, mixed-ownership reform, in which private capital is allowed to invest in government-run enterprises, is still unclear whether the mixed-ownership model is effective to improve SOE’s efficiency, although Li, Qiu, and Wang (2019) find that technology conglomerates produce more patents that are novel and/or with greater impact.

In China’s 40 years of reform, both theory and practice have proved the positive effect of reform on productivity and innovation because the state sector has significantly lower efficiencies in both R&D and productive activities (Zhang, Zhang, & Zhao, 2003). Prior articles mostly exploit the impact from the split share reform in 2005 (Tan, Tian, Zhang, & Zhao, 2015) or the privatization of SOEs (Gan et al., 2018). With the economic development, the current reform has stepped into the New Normal. Shi and Zhang (2018) study the corporate investment and its structural change by the view of state-owned property right, implying that both SOEs and POEs...
reduced their investment in the new normal economy. This paper aims to exploit the relationship between China’s current state-sector reform and corporate innovation. In order to provide a helpful suggestion to deepen reform, this study takes the mixed-ownership reform as an exogenous regulatory shock to analyzing the impact of the current reform on the SOEs’ innovation.

In order to identify the role of mixed-ownership reform, we adopt the difference-in-difference (DiD, hereafter) approach to compare the change of the innovation activities of SOEs\(^1\) and POEs. We use POEs as the control group\(^2\), and use SOEs as the treated group to estimate the effect of mixed-ownership reform. This study confirms the benefit of mixed-ownership reform on corporate innovation. The mixed-ownership reform significantly improves corporate innovation, no matter which proxy variable we use to measure it. \(\text{Woo, Hai, Jin, and Fan}(1994)\) address that the criterion for successful SOE reform should include intertemporal efficiency and SOEs’ contribution to macroeconomic stability. Our paper provides strong evidence on this.

We use PSM method and structural models to deal with the following two concerns. First, SOEs and POEs are not naturally comparable because of the particular property rights in China. In order to alleviate the influence from the natural differences, we use the propensity score matching (PSM) method to match SOEs and POEs, and employ the matched samples to estimate regression. The second concern is China’s unbalanced regional development and the protectionism in monopoly industry, which may cause a gap in reform effect. In particular, the mixed-ownership reform may have a greater impact on monopoly industries or eastern regions. In order to deal with these endemic phenomena, we divide the total sample into two sub-samples of monopoly or competitive industries, and regional structure (eastern and non-eastern). The heterogeneities in region and industry are reported in this paper. We find that innovation is improved higher in the eastern region. The heterogeneity in industry shows an interesting finding. The impact of mixed-ownership reform is greater in monopoly industry than that in competitive industry while this reform was aimed to practice in the competitive industries.

Using the PSM-DID approach, we find that mixed-ownership reform shows a significant impact on corporate innovation activities, which not only improves the R&D investment, but also increases the number of all patents and invention patents. In addition, compared to competitive industries, the impact of mixed-ownership reform on corporate innovation in monopoly industries is higher. Moreover, the impact of the mixed-ownership reform on corporate innovation in the eastern region is more significantly larger than that in the non-eastern region. Additional tests also help isolate the effect of intervention from macro-economic effects, including house price, private employees, credit and equity finance. Finally, we use 2SLS to check the endogeneity (Romer, 1990) by using regional highway as the instrumental variable. The results are robust.

Our study extends beyond the question of corporate innovation to government intervention. Prior literature regard government intervention as a response to market failure. Hao and Lu (2018) recently examine how government intervention affects firms’ investment allocation, finding that government intervention results in promoting corporate investment in fixed assets and reducing R&D investment. But our study shows a positive effect from government intervention, revealing that government calls for mixed-ownership reform improves SOEs’ innovation. This finding is consistent with the conclusion of Brav, Jiang, Ma, and Tian (2018) who find that hedge funds improve firms’ innovation. They use a special background, where activists lead to higher innovation while firms’ control rights do not change. We provide stronger evidence when the state ownership decreased in SOEs, even it is only a prospect announced by the government in 2013. We also checked other two events, the first time state ownership dropped down after 2013, and the time SOEs published their mixed-ownership reform announcements.

The second contribution is that our study enriches the empirical research on the influence of China’s state-sector reform on SOEs’ innovation. Xu (2011) considers China’s institution as a regionally decentralized authoritarian system to solve the “China Puzzle”. Recently, some distinguished studies go further in this direction and analyzed two events, distance-decentralization link (Huang, Li, Ma, & Xu, 2017) and direct sales to insiders (Gan et al., 2018). This paper tries to study a third China SOE reform, ongoing mixed-ownership reform. Different with any other prior reform, it is not an isolation reform Shleifer (1998) pointed but a new trend, amalgamating to each other. POEs will get more financing using SOEs’ platform, while SOEs will improve their efficiency by introducing POEs’ corporate governance (Shleifer & Vishny, 1999; La Porta, Lopez-De-Silanes, & Shleifer, 1999). This study also complements the impact of regional effect, industrial effect and macroeconomic variables on the SOEs reform.

Furthermore, we even find that this reform improves POEs innovation as well because it is a new way of political connection by merging with SOEs rather than connecting to a politician. Recent emerging literature begin to focus on the latter. D’Souza and Nash (2017) specifically consider the private benefits of state control. They present evidence that cross-listings are more likely when the private benefits of state control are lower. Schoenherr (2019) using Korean background to documents that political connections results in allocative distortions, because state firms allocate significantly more contracts to private firms with a CEO connected to the same network of politicians. Our paper provides a new perspective that POE invests more on R&D after it is mixed-owned, which is a new form of political connection. Chen, El Ghoul, Guedhami, and Wang (2017) find that government ownership weakens investment-Q sensitivity, thereby increasing investment inefficiency. They find that the relation between foreign ownership and investment efficiency is stronger when governments relinquish control which is consistent with our findings for SOEs. But for POEs, we still find the R&D inputs are improved, which may result from higher cash holding for those POEs mix-reformed, which is consistent with the finding of Chen, El Ghoul, Guedhami, and Nash (2018). China’s ongoing mixed-ownership is a win-win strategy for both SOEs and POEs. Fan, Huang, Morck, and Yeung (2017) find Chinese firms in the 2000’s are more vertically integrated than the U.S. firms in the

---

\(^1\)SOEs are defined as the firms whose actual controller or major shareholder is State-owned Assets Supervision and Administration Commission of the State Council (SASAC, hereafter).

\(^2\)The reason why we select POEs as control group instead of SOEs that are not influenced by mixed-ownership reform is based on two points, which will be illustrated in Section 3.1.
1990s, especially more common where legal institutions are weaker and where regional governments are of lower quality or more interventionist. This paper shows a new page of China corporate integration, not vertical but in ownership type.

The rest of the paper is organized as follows. Section 2 reviews the background and develops our hypotheses. Section 3 describes the sample and provides summary statistics. Section 4 reports empirical results. Section 5 is robustness check. Finally, Section 6 concludes.

2. Background and hypothesis development

2.1. Background and literature review

2.1.1. China’s mixed-ownership reform

The state-owned enterprise reform has never stopped since China’s Reform and Opening-up. From introducing township enterprises as supplements, the separation of government and enterprises, the reform of stock market system, to the ongoing mixed-ownership reform, SOE reform has been implemented for nearly 40 years. This is one of the longest and the most successful reforms on property right ownership, and has realized improving the efficiency in both production and resource allocation. It may attract the focus of economic development and other academic research. Today, the mixed-ownership reform has now become the core of the current SOE reform in China. Table 1 concludes the detailed policies and guidelines in this process of China’s SOE reform.

Table 1
The process of China’s SOE reform.

| Date     | Announcer                                      | Policies and guidelines                                                                 |
|----------|------------------------------------------------|-----------------------------------------------------------------------------------------|
| Mar, 1984| No. 4 document by CPC Central Committee        | Township enterprise began to be introduced into consumer industry as an important supplement of China’s SOEs in heavy industry. |
| Nov, 1993| The 3rd Plenary Session of the 14th CPC Central Committee | Decision on Several Issues Concerning the Establishment of a Socialist Market Economic Structure. |
| Mar, 2003| The 10th people’s congress                      | The establishment of SASAC.                                                            |
| Apr, 2005| China Securities Regulatory Commission          | Reform of split shares.                                                                |
| Nov, 2013| The 3rd Plenary Session of the 18th CPC Central Committee | Decision of the central committee of the communist party of china on several major issues concerning comprehensively deepening reform. Actively developing a diversified ownership economy by mixed-ownership reform. |
| Jul, 2014| SASAC                                           | Establishing the pilot for central enterprises to develop mixed-ownership economy.       |
| Aug, 2015| 1 + N Files                                     | 1. Improving the efficiency of capital allocation and operation in SOEs.                |
|          |                                                 | 2. Perfecting the modern enterprise system and improving efficiency of SOEs.             |
| Sep, 2015| The State Council                               | 1. Improving the economic efficiency and innovation efficiency of SOEs in competitive industries and field through the mixed-ownership reform. |
|          |                                                 | 2. Accelerating technological innovation, management innovation and business model innovation in SOEs focusing on R&D innovation through introducing non-state capital. |
|          |                                                 | 3. Alleviating the damage of agency problem by setting up an operating mechanism with multiple ownership structure, effective internal constraints, and flexible operation. |
|          |                                                 | 4. Weakening the influence of administrative appointment by building up a corporate governance mechanism with clear property rights and incentive system. |
| Feb, 2016| SASAC media conference                          | Establishing the pilot for ESOP\textsuperscript{a} in SOEs.                           |
| Sep, 2016| National Development and Reform Commission       | Proposed the guideline that reform should improve the operating ability and innovation efficiency by setting up a corporate governance structure with coordinated operation and effective control and perfecting the market-oriented incentive and restraint mechanisms. |
| Dec, 2016| Central Economic Work Conference                | The reform of the mixed-ownership system is an important breakthrough in deepening the reform of SOEs. |
| Apr 2017 | SASAC                                           | The designs of the 1st and 2nd batches of reform pilot.                                 |
| Oct 2018 | SASAC                                           | The designs of the 3rd batches of reform pilot.                                        |
| April 2019| SASAC                                          | The designs of the 4th batches of reform pilot.                                        |

\(\text{a ESOP: Employee Stock Ownership Plan.}\)

1990s, especially more common where legal institutions are weaker and where regional governments are of lower quality or more interventionist. This paper shows a new page of China corporate integration, not vertical but in ownership type.

The rest of the paper is organized as follows. Section 2 reviews the background and develops our hypotheses. Section 3 describes the sample and provides summary statistics. Section 4 reports empirical results. Section 5 is robustness check. Finally, Section 6 concludes.
These policies mentioned above show that China’s mixed-ownership reform allows other capital to merge with SOEs, which focus and aims to overcome the problems and shortcomings of the state-owned enterprises, and to establish a more efficient and modern enterprise system. Zhang (2020) focus on the measurement of intangible assets and M&A manipulation considering the effect from this reform. This paper aims to exploit whether the mixed-ownership reform is able to improve firm’s efficiency. Since the key resource of growth is innovation in modern economy, we only focus on the improvement of innovation instead of other perspectives of efficiency. Our paper could provide new evidence to the existing literature on SOE reform. Majority of previous articles addressed that SOEs are not willing to innovate, but this paper shows a significant increase on SOEs after this reform even the SOE is not belong to the list of 4 batches.

2.1.2. State-ownership and corporate innovation

SOEs have always been considered to be less efficient (Allen, Qian, & Qian, 2005; Che & Qian, 1998; Cull & Xu, 2005; Fan, Wong, & Zhang, 2007). Chen et al. (2017) find that government ownership weakens investment-Q sensitivity, thereby increasing investment inefficiency using newly privatized firms from 64 countries. Shi and Zhang (2018) find corporate investment heterogeneity in China due to SOE and POE’s different dynamic shifts of objective functions. In their 3-stage structural models, they find that SOEs reduced their investment significantly due to the manager’s concerns on their own job promotions; therefore, they prefer quiet life (Bertrand & Mullainathan, 2003; Stein, 2003) rather than empire building even in China’s new normal.

This risk aversion restricts SOE’s investment. Hao and Lu (2018) examine government tends to reduce R&D investment because R&D investments are riskier and take much longer to be realized. Gu (2016) uses a standard real options model and predicts a strong positive interaction effect between R&D investment and product market competition. According to Gu’s prediction, R&D should also decrease in SOEs since they are more likely in less competition, which also support Hao and Lu (2018)’s finding. Brav et al. (2018) study how hedge fund activism reshapes corporate innovation, finding that R&D expenditures will decrease after hedge fund enters. Boubakri, Goul, Guidami, and Megginson (2018) document that the effect of government ownership on valuation is influenced by financial market development and the quality of government.

There are several reasons why SOEs spend less on R&D. First, policy burdens (Lin & Tan, 1999). The government will impose strong interventions on business operations in order to achieve certain political goals (Shleifer & Vishny, 1994), which will make SOEs to take short-term investment decisions under special political goals, to abandon innovative investment projects with higher risks and profits, and to generate fewer novel technological innovations (Gao, Hsu, & Li, 2018). The cross-shareholding between different categories of capitals, which is one target of the mix-ownership reform, will increase the cost of government intervention in privatized companies (Sappington & Stiglitz, 1987), helping companies to carry out more value-added innovation activities.

Second, corporate governance. SOEs have more serious agency problems due to the lack of effective incentives and supervision mechanisms for managers (Laffont & Tirole, 1993). Mixed-ownership reform will help enterprises improve corporate governance, reduce managers’ moral hazard, and encourage enterprises to carry out innovative activities by the higher proportion of non-state-owned shares, employee stock ownership plan, and the better state-owned capital operation system. This may be consistent with Aghion, Van Reenen, and Zingales (2013), who find greater institutional ownership is associated with more innovation, which explore the mechanism contrasting the “lazy manager” hypothesis.

Third, the administrative monopoly. Unlike other forms of monopoly, administrative monopolies create barriers through licenses to reduce competitors, and result in the lag in productivity and innovation. The mixed-ownership reform introduces competition by breaking the monopoly form, forcing SOEs to improve production efficiency and innovation. Thus, we will introduce monopoly industry effect into consideration.

2.1.3. Heterogeneities

Governments around the world make use of financial markets including sustained historically low interest rates to stimulate business investment, but it is still recovered slowly, even as the recovery continued (Gutiérrez & Philippon, 2017). Crouzet and Eberly (2019) examine this weak investment puzzle because the composition of capital stock changed over time. Firms increase intangible capital other than PPE, which is the consequence of rising concentration in US industries. On the contrary, Chinese government introduced another tool, mixed-ownership reform, resulting in lower the concentration, opposite to U.S.

We also exploit the impact of spatial distribution or regional differences on innovative activities. The reason is that there is a widespread agglomeration of innovative activities around the world, no matter in developed countries (Audretsch & Feldman, 1996) or in emerging markets (Tan, Cheng, Lei, & Zhao, 2017). Aggregation of innovative activities not only creates regional differences in innovation input and output, but also causes technological spillover which will affects R&D activities of this area and surrounding areas. Shang, Poon, and Yue (2012) use spatial autoregressive models and find that regional knowledge spillover has a positive effect on innovation activities and economic growth. Song and Zhang (2017) find that the spillover effect exists in the regional R&D activities widely, both in innovation input and output. As a result of it, regional imbalance will have a significant impact on the effect of mixed-ownership reform. Rong, Wang, and Gong (2016) use the DID method to analyze the effect of the mixed-ownership reform on the SOEs’ innovation activities. Huang (2010) find that the innovation efficiency in the eastern region is higher than that in other regions.

2.2. Hypotheses

Sampat (2018) recently summarized the empirical evidence on patents and innovation, emphasizing a global environment, i.e. outside the U.S., is one of the topics of ongoing research. They also point out that heterogeneous effects of innovation appear to
depend on various other institutional effects. We aim to exploit the effect of innovation from three perspectives. First, general question on demonstrating the impact of the state ownership on corporate innovation (Chen et al., 2017). Second, heterogeneities in region and industry. Lerner and Seru (2017) summarized the regional differences in innovation. Third, exogenous shock from regulations. There is a positive influence of China's SOEs reform on innovation output (Tan et al., 2015). Recently, Gao and Zhang (2019) find that innovations significantly decrease after Sarbanes-Oxley Act (SOX) of 2002, because the managers are required to report the effectiveness of their company’s internal control over financial reporting. When POEs are mix-reformed, this will result in an increase of innovation with the state ownership increasing.

Following these above literature, we build up the hypothesis as follows,

**H1.** The mixed-ownership reform can significantly improve the innovation activities for SOEs.

**H2.** The impact of mixed-ownership reform on innovation may be higher in eastern region than in non-eastern region.

Furthermore, we also test the effects on POEs and heterogeneity of industries as well.

### 3. Data and sample overview

#### 3.1. Data sources

To empirically assess the effect of mixed-ownership reform, we collect financial data from the A-share listed companies in China, which belongs to manufacturing industry, using the annual data of these listed companies in 2011–2015. The reason why we select manufacturing enterprises is that the innovation activities plays more important role in manufacturing industry. Our corporate-level data are mainly collected from WIND China Financial database and CSMAR database. In order to ensure the integrity and credibility of the sample data, we remove the ST and *ST companies to avoid the impact of abnormal values, delete companies lacking of financial data and abnormal companies, remove companies listed after 2008 to ensure companies are listed more than 3 years, and delete these companies whose leverage is more than 1. Finally, we get 654 listed companies, and 3270 observations.

In addition, in order to obtain the data of company's innovation activities, we collect R&D expenditure and the number of patent application of the sample companies from the WIND database, the CSMAR database and China State Intellectual Property Office (SIPO) database, respectively. The definitions of variable and data resource are shown in Appendix A.

Finally, we use DiD analysis both the same event and individual events. Gao and Zhang (2019) use the former from the exogenous regulation shock of 2002, we use 2013 as the similar to identify the effect from mixed-ownership reform. In addition, Jia and Tian (2018) use an individual event, change in the number of direct flights to do DiD analysis. In order to assess the effect from the mixed-ownership reform, we hand-collect the date of each firm when it posted their announcements of mixed-ownership reform, including SOEs and POEs. Based on this hand-collected data, we construct the list of the treated group being mixed, and we are able to get more details on the mixed directions, SOEs merge POEs, or POEs merge SOEs. For SOEs, we also use a second measurement of mixed-ownership reform by using the state ownership data from CSMAR database.

#### 3.2. Summary statistics

Table 2 reports descriptive statistics for the variables used in our analysis, in which Panel A, Panel B and Panel C report the summary statistics of full sample, POE subsample and SOE subsample, respectively. For the full sample in Panel A, the average R&D expenditure is 1.9%, the maximum is 9.4%, the minimum is 0. From the R&D output, total number of patents is 39.49, among of which, the invention patents are 17.33 in average, the average number of utility models and design patents is 22.16 in average. The average annual return on net assets is 6.9%, and the annual growth rate of operating income is 13.2. The number of SOE is 57.2%, more than one half.

We also divide the sample into SOE and POE sub-samples based on the nature of state ownership. As Panel B and Panel C of Table 2 show, the difference between SOEs and POEs in each percentile is huge, which means that there exists gaps between SOEs and POEs in innovation and other features. For example, the size in SOE is higher than that in POEs, but the growth and profitability of POEs are better than SOEs, consistent with the findings of Shi and Zhang (2018). It may result from the political connection which is helpful to credit access.

Table 3 compares the difference between SOEs and POEs by using two-independent-sample t-test. The result is shown in Table 3. It shows that the R&D investment of SOEs is lower than that of private enterprises, while the number of patent applications is obviously higher than that of private enterprises. In addition, the leverage of SOEs is significantly higher than that of private enterprises, which is consistent with the previous empirical works. The performance and growth of private enterprises was significantly higher than the SOEs, shown by the ROE and operating income growth rate. Last but not least, the size of SOEs will be significantly larger than that of private enterprises.

Figs. 1 and 2 compare the regional difference from the reform of R&D input and output. Fig. 1 shows the changes in the ratio of total R&D expenditure and total market capitalization. On the one hand, provinces with large R&D expenditure are concentrated in

---

4 Brandt, Van Biesebroeck, Wang, and Zhang (2017) also examine Chinese manufacturing firms, studying the effect of WTO accession on their evolution of markups and productivity.
coastal areas such as Zhejiang (2.21% before and 2.44% after) and Jiangsu. On the other hand, with the advance of the reform, the R&D input in each region has a certain degree of improvement, especially in the eastern region and east-central region. For example, the annual R&D input in Anhui Province is 1.06% before the reform, which increases to 1.81% after the mixed-ownership reform. Fig. 2 demonstrates the changes in the annual number of invention patent applications in each province. The invention patent application occurs mainly in the eastern Yangtze River Delta, the Pearl River Delta and Beijing area. What’s more, we limit our research period to be short to avoid the interference of technological evolution. Fig. 2 shows a positive impact of the mixed-ownership reform on invention patent application in the eastern region and some cities of central region, such as Shandong, Anhui and Henan provinces. For example, the number of application in Shandong directly rises from 799 (2011–2012) to 1366 (2013–2015),

### Table 2
The descriptive statistics of variables.

|          | Panel A: Total sample | Panel B: Sample of POEs | Panel C: Sample of SOEs |
|----------|-----------------------|-------------------------|-------------------------|
| Mean     | SD                    | Min                     | Q1                      | Median                  | Q3                      | Max                     | N         |
| RD_TA    | 0.019                 | 0.19                    | 0.00                    | 0.004                   | 0.015                   | 0.029                   | 0.094     | 3269    |
| Patent   | 39.491                | 193.480                 | 0.00                    | 0.000                   | 4.500                   | 20.000                  | 3674.000  | 3270    |
| Patent1   | 17.332                | 102.657                 | 0.00                    | 1.000                   | 1.000                   | 1.000                   | 8.000     | 3270    |
| Patent23  | 22.160                | 107.871                 | 0.00                    | 1.000                   | 1.000                   | 1.000                   | 8.000     | 3270    |
| SOE      | 0.572                 | 0.495                   | 0.00                    | 1.000                   | 1.000                   | 1.000                   | 1.000     | 3270    |
| Leverage | 0.492                 | 0.187                   | 0.076                   | 0.358                   | 0.502                   | 0.636                   | 0.873     | 3270    |
| ROE      | 0.069                 | 0.121                   | -0.448                  | 0.022                   | 0.064                   | 0.123                   | 0.427     | 3270    |
| SalesGrowth | 0.132             | 0.257                   | -0.433                  | -0.017                  | 0.107                   | 0.237                   | 1.195     | 3270    |
| HiTechIndustry | 0.691       | 0.462                   | 0.00                    | 1.000                   | 1.000                   | 1.000                   | 1.000     | 3270    |
| Liquidity | 0.553                 | 0.170                   | 0.174                   | 0.432                   | 0.562                   | 0.679                   | 0.889     | 3269    |
| Labor    | 8.027                 | 1.102                   | 4.868                   | 7.258                   | 8.025                   | 8.757                   | 10.689    | 3270    |
| Tangibility | 0.407             | 0.195                   | -0.005                  | 0.264                   | 0.390                   | 0.539                   | 0.869     | 3270    |
| MB       | 0.796                 | 0.182                   | 0.280                   | 0.687                   | 0.848                   | 0.943                   | 1.000     | 3270    |

### Table 3
Difference between SOEs and POEs: t-test of the mean of variable.

|          | SOE        | POE        | Diff       | t-test    | p-Value |
|----------|------------|------------|------------|-----------|---------|
| RD_TA    | 0.018      | 0.021      | -0.004***  | -3.642    | 0.000   |
| Patent   | 56.064     | 25.340***  | 25.724     | 5.685     | 0.000   |
| Patent1  | 24.959     | 10.715***  | 10.244     | 4.925     | 0.000   |
| Patent23 | 31.104     | 13.438***  | 17.666     | 5.502     | 0.000   |
| Leverage | 0.517      | 0.045***   | 0.472      | 8.937     | 0.000   |
| ROE      | 0.066      | 0.119      | 0.053      | 0.427     | 0.000   |
| SalesGrowth | 0.123    | 0.102     | 0.021      | 0.227     | 0.000   |
| HiTechIndustry | 0.678     | 0.502     | 0.176      | 1.195     | 0.000   |
| Liquidity | 0.547      | 0.552      | 0.005      | 0.889     | 0.000   |
| Labor    | 8.289      | 8.995      | 0.706      | 10.689    | 0.000   |
| Tangibility | 0.389      | 0.522      | 0.133      | 0.869     | 0.000   |
| MB       | 0.770      | 0.940      | 0.170      | 1.000     | 0.000   |

Notes: This table show the result of t-test in corporate innovation and characters. ***p < 1%, **p < 5%, *p < 10%.

coastal areas such as Zhejiang (2.21% before and 2.44% after) and Jiangsu. On the other hand, with the advance of the reform, the R&D input in each region has a certain degree of improvement, especially in the eastern region and east-central region. For example, the annual R&D input in Anhui Province is 1.06% before the reform, which increases to 1.81% after the mixed-ownership reform.

Fig. 2 demonstrates the changes in the annual number of invention patent applications in each province. The invention patent application occurs mainly in the eastern Yangtze River Delta, the Pearl River Delta and Beijing area. What’s more, we limit our research period to be short to avoid the interference of technological evolution. Fig. 2 shows a positive impact of the mixed-ownership reform on invention patent application in the eastern region and some cities of central region, such as Shandong, Anhui and Henan provinces. For example, the number of application in Shandong directly rises from 799 (2011–2012) to 1366 (2013–2015),
Fig. 1. Comparison of R&D input in each province. We calculate the sum of R&D expenditure and asset of the sample listed company which is located in the same province. R&D input in province level is the ratio of total R&D expenditure over total asset. Provinces with high R&D input are concentrated in eastern coastal areas.
(a) Innovation patent application before the mixed-ownership reform

(b) Innovation patent application after the mixed-ownership reform
which increase of nearly 70%.

Fig. 3 shows the comparison of innovation efficiency in each province. Fig. 3(a) shows SOEs spend less on R&D than POEs do, which is consistent with previous literature that SOEs were unwilling to R&D in some provinces, ex. Anhui, Beijing, Guangdong, Hubei, Tianjin and Zhejiang. Still, some provinces show an adverse trend, ex., Shaanxi, Shanghai and Shanxi. Fig. 3(b) shows an upward tendency of the number of patent application in SOEs in eastern region and east-central region. Taking these phenomena into consideration, we find the mixed-ownership reform can increase the innovation efficiency of SOEs in the eastern region and east-central region, because they improve the patent application without a significant increase in R&D input after reform.

3.3. State ownership

A direct impact from the mixed-ownership reform is the ownership type. Fig. 4(a) reports the percentage of POEs and SOEs in each year. It shows a rising trend off POEs after the reform. The percentage of POEs is keeping rising after the reform, about 43.4% in 2014 and 45% in 2015, compared to 42% before the reform. We further exploit the ownership structure of SOEs by three types, the first shareholder owns more than 50% equities, from 20% to 50%, or less than 20%. Fig. 4(a) shows SOEs of the first type is dropping sharply since the mixed-ownership reform.

Fig. 4(b) reports the state ownership percentage in each year. This ongoing reform is not simply the state sector reform as China practiced before, which showed a decline of state ownership. It also happens in POEs which were or will be merged or invested by the state, therefore state ownership is rising after the reform as Fig. 4(b) shows.

Table 4 shows the difference between monopoly industry and competitive industry. Table 4 Panel A reports the largest shareholder’s block in SOEs or POEs of each year. In SOEs, the largest shareholders have more equities in monopoly industry, On the contrary, for POEs, the largest shareholders keep more equities in competitive industry.

In Table 4 Panel B, we divide the sample holding state ownership into three types, absolute state controlling (state ownership more than 50%), relative state controlling (20% ≤ state ownership ≤ 50%), and out of state controlling (state ownership less than 20%). Table 4 Panel B reports the state ownership in each subsample.

4. Empirical results

4.1. State ownership and innovation

4.1.1. Benchmark model

We firstly exploit the effect from the mixed-ownership reform, dealing it with an exogenous shock on all the firms. Considering the heterogeneities of state ownership, we use the DID approach to measure the effect of reform, in which SOEs are seen as treatment group and POEs are defined as control group. Referring to the relevant literature (Rong et al., 2016), we set the basic empirical model as follows:

\[ Y_{it} = \beta_0 + \beta_{SOE_{it}} + \gamma_{SOE_{it}} \cdot Post_{it} + \alpha X_{it} + \epsilon_{it} \]  

(1)

where \( Y_{it} \) represents the \( i \)th firm’s innovation capacity in year \( t \), which is measured by innovative input and innovative output. Innovation input is measured by R&D expenditure (Rong et al., 2016), and innovative outputs are measured by patent applications (Tan et al., 2015). Taking into account the type of patent, we divide innovation output into the number of total patents (Patent), the number of invention patents (Patent1), and the number of utility patents and design patents (Patent23) respectively. \( SOE_{it} \) is a dummy variable measuring the nature of property right\(^5\), which equals 1 when firm \( i \) belong to SOEs in year of \( t \). Post is the time dummy variable of the mixed-ownership reform, which equals 1 when the year is after 2013. \( X_{it} \) is a series of control variables, including corporate financial leverage (Leverage), profitability (ROE), firm growth (SalesGrowth), firm size (Size), corporate liquidity assets (Liquidity), the number of employees (Labor), tangible assets (Tangibility) and market-book ratio (MB). Besides, regression results include firm fixed effect\(^6\). In order to control the endogeneity, all the independent variables were delayed for one observation. All non-binary variables are winsorized at the 1st and 99th percentiles.

Table 5 reports the estimated results of the DID approach based on the total sample, where R&D investment, the number of total patents, the number of invention patent, the number of utility and design patents considered as the measure of innovation respectively. Among the results, the coefficient of the interaction (SOE*Post) in column (1) to column (3) is significantly positive, which indicates that the mixed-ownership reform has a significant positive effect on the corporate innovation activities, no matter what proxy we use to measure corporate innovation. More specifically, the mixed-ownership reform can promote the R&D investment, the

\(^5\) The enterprise type is divided according to the corporate property right index in the Wind CFD.

\(^6\) Here, we don’t control the industry effect. On the one hand, our samples are only related to the manufacturing industry. On the other hand, we are inspired by the existing literature, like Guariglia (2008) and Hovakimian (2009).
Graphs by province

(a) Change of R&D input in each province.

(b) Change of R&D output in each province.
total number of patent applications and the number of invention patent applications, which means the Hypothesis H1 is supported. However, the coefficient of the interaction (SOE*Post) in model (4) is not significant. We believe the main reason is that utility patents and design patents are not a true and objective measure of corporate innovation for its large maneuverability.

In addition, the coefficient of property rights in column (1) is significantly negative, indicating that the state ownership has a marked negative impact on R&D investment, which means the R&D investment of SOEs is less than that of private enterprises under the control of other factors. However, the coefficient in column (2) ~ column (4) are not significantly negative, showing that the impact of property rights on the number of patents is negligible.

Table 5 also shows the impact from other factors. Firstly, the corporate financial leverage has a significantly negative impact on R&D investment, indicating that companies will reduce R&D investment if there is high financial risk and financial constraints caused
by the high leverage. Secondly, the market-book value has a significantly negative impact on corporate R&D investment, because corporate managers have motivation to reduce R&D investment to avoid investment failures when their market valuations are high.

### 4.1.2. PSM-DID

In order to do robustness test, the PSM method is used to match SOEs and POEs. Referring to the study of Lu and Shi (2012) and Tan et al. (2015), the matching variables selected in this paper mainly include: financial leverage, profitability, company growth, Table 4

#### Table 4

**Difference between monopoly industry and competitive industry.**

|                  | SOE Median | Monopoly industry | Competitive industry | POE Median | Monopoly industry | Competitive industry |
|------------------|------------|-------------------|----------------------|------------|-------------------|----------------------|
| 2011             | 38.74      | 38.92             | 36.13                | 28.74      | 27.04             | 30.11                |
| 2012             | 37.97      | 38.77             | 36.11                | 28.25      | 26.71             | 28.87                |
| 2013             | 37.42      | 38.73             | 35.83                | 27.98      | 27.03             | 28.84                |
| 2014             | 37.30      | 38.97             | 36.00                | 28.00      | 26.48             | 29.69                |
| 2015             | 36.74      | 37.65             | 36.02                | 28.11      | 27.03             | 29.41                |
| Total            | 37.79      | 38.79             | 36.02                | 28.14      | 26.92             | 29.24                |

#### Panel B. State ownership

|                  | Stateown < 20% | Monopoly industry | Competitive industry | Stateown ≥ 50% | Monopoly industry | Competitive industry |
|------------------|----------------|-------------------|----------------------|----------------|-------------------|----------------------|
| 2011             | 6.06           | 7.14              | 37.48                | 33.57          | 55.56             | 50.51                |
| 2012             | 5.07           | 6.23              | 34.52                | 34.19          | 55.55             | 60.75                |
| 2013             | 6.13           | 5.61              | 35.36                | 31.45          | 55.55             | 60.75                |
| 2014             | 5.37           | 7.24              | 36.16                | 41.54          | 58.98             | 57.78                |
| 2015             | 5.11           | 5.11              | 35.40                | 38.28          | -                 | -                    |
| Total            | 5.44           | 6.22              | 35.28                | 33.57          | 55.56             | 59.27                |

#### Table 5

**Regression results of the full sample.**

|                  | (1) RD_TA | (2) Patent | (3) Patent1 | (4) Patent23 |
|------------------|-----------|------------|-------------|--------------|
| DID              |           | PS-M-DID   | DID         | PS-M-DID     |
| SOE              | -0.005*** | 1.465      | -1.767      | 3.232        |
| (0.002)          |           | (14.596)   | (9.513)     | (7.906)      |
| SOE*Post         | 0.003***  | 0.003***   | 12.156***   | 9.869***     |
| (0.001)          | (0.001)   | (4.315)    | (3.143)     | (2.812)      |
| Leverage         | -0.015**  | -0.014**   | 119.683**   | 115.195***   |
| (0.007)          | (0.007)   | (50.247)   | (38.519)    | (32.748)     |
| ROE              | 0.001     | 0.001      | 31.227      | 26.819**     |
| (0.002)          | (0.002)   | (18.657)   | (13.469)    | (12.160)     |
| SalesGrowth      | -0.001    | -0.001     | -4.975      | -7.050       |
| (0.001)          | (0.001)   | (7.062)    | (5.353)     | (4.603)      |
| Size             | -0.004*** | -0.003***  | 3.981       | 2.751        |
| (0.001)          | (0.001)   | (6.707)    | (5.039)     | (4.372)      |
| Liquidity        | -0.001    | -0.001     | -22.844     | -20.333      |
| (0.003)          | (0.004)   | (26.449)   | (19.406)    | (17.238)     |
| Labor            | 0.001     | 0.000      | 6.954       | 5.895        |
| (0.001)          | (0.001)   | (6.205)    | (4.747)     | (4.044)      |
| Tangibility      | -0.008    | -0.007     | 102.633**   | 93.685***    |
| (0.006)          | (0.007)   | (47.102)   | (35.801)    | (30.698)     |
| MB               | -0.012**  | -0.011**   | 1.515       | 23.341       |
| (0.004)          | (0.004)   | (27.827)   | (20.517)    | (18.136)     |
| Constant         | 0.067***  | 0.064***   | -143.429**  | -156.937***  |
| (0.010)          | (0.011)   | (79.839)   | (58.604)    | (52.035)     |
| Frim FE          | Yes       | Yes        | Yes         | Yes          |
| Match            | No         | Yes        | No          | Yes          |
| N                | 3269       | 3119       | 3269        | 3119         |
| Adj-R²           | 0.682      | 0.690      | 0.815       | 0.710        |

Notes: Report in parentheses are standard error clustering in firm level. ***p < 1%, **p < 5%, *p < 10%.

In order to do robustness test, the PSM method is used to match SOEs and POEs. Referring to the study of Lu and Shi (2012) and Tan et al. (2015), the matching variables selected in this paper mainly include: financial leverage, profitability, company growth,
company size and the industry. We use Logit model to capture the relationship between property right and selected variables in this paper to achieve a nearest match.

Using this Logit model and the firm data in 2012, we employ the method of nearest neighbor matching, which means we want to make SOEs matched to POEs according to the matching variables. We remove these SOEs and POEs that could not be matched and acquire 378 SOEs and 276 POEs respectively. The test of the result of PSM is shown in Appendix B. Then we check the impact of the mixed-ownership reform by estimating with the propensity score method sample. Taking the bias caused by the heterogeneity between industries into account, we cluster error in firm level.

The coefficients of the interaction in Table 5 are significantly positive in the PSM sample, which proves the active role of mixed-ownership reform on the innovation activities once again. What’s more, the coefficient of the interaction for Patent and Patent1 are also significantly positive, proving that the mixed-ownership reform has a positive effect on the increasing in the number of total patents and invention patents. However, the coefficient of the interaction for Patent23 are still not significant, so we believe that the mixed-ownership reform does not increase the number of utility patents and design patents.

Therefore, our empirical results prove the positive role of the mixed-ownership reform and this promotion is mainly manifested in two aspects: Firstly, the mixed-ownership reform can significantly enhance the number of total patents and invention patents. The conclusions are consistent with the results of the DID approach under the PSM method, so we prove the Hypothesis H1 above again.

4.2. Industrial and regional distributions

4.2.1. Eastern region effect

Table 6 reports the regression results of subsample based on the different regions according to the categories of National Bureau of Statistics of China. Since Patent23 is not the real patent as the last table shows, we do not report the regression results of Patent23 here. Column (1), (4), and (7) report the sub-sample regression results of eastern region, column (2), (5) and (6) report the subsample regression results of non-eastern region, and column (3), (6) and (9) report the total sample regression results with the interaction of regional dummy variable. The coefficients of interaction in column (1) and column (2) are significantly positive, and the coefficient of interaction in column (2) is smaller than that in column (1), which shows that the mixed-ownership reform plays a more remarkable and lager role on corporate R&D investment in the eastern region. The coefficients of interaction in column (3) is also significantly positive while that in column (4) is insignificant. It implies that the influence of mixed-ownership reform on
innovation output (measured by total patents and invention patents) is significant effect in the eastern region but not significant in the non-eastern region. Column (9) still shows the same feature that the effect of reform on invention patent applications is greater in the eastern region than the other regions with the progress of the mixed-ownership reform.

In summary, our results support Hypothesis 2. Compared with non-eastern areas, the impact of mixed-ownership reform on the innovation activities is more significant in the eastern areas. Our explanation is that the more developed economy and more advanced technology in the eastern region gives the SOEs in the eastern region advantages to update technology and explore new corporate governance models continuously. Based on these natural advantages and the mixed-ownership reform, SOEs in the eastern region could attract more outstanding private capital and foreign capital to participate in their corporate governance and enjoy the achievement of the mixed-ownership reform.

4.2.2. Monopoly industry effect

Inspired by Li et al. (2019), which suggesting the overconfident managers will be good innovators only in innovative industry, we also test the effect from the industrial distribution. Table 7 reports the regression results of the subsamples in monopoly industries and competitive industries. The interaction coefficient in column (1) and column (2) is significantly positive, indicating that the mixed-ownership reform has a significant role in promoting the innovation expenditures of SOEs both in the monopoly industry and the competitive industry. In addition, the impact of mixed-ownership reform is greater in the monopoly industry than that in the competitive industry because the coefficient of interaction in column (1) is larger than that in column (2).

The coefficients of interaction in column (3) and column (4) are also significantly positive, showing that the mixed-ownership reform has a significant effect on the increasing of the number of total patents both in the monopoly industry and the competitive industry. The coefficients of the interaction in column (5) and column (6) are also positive. To sum up, our empirical results support the Hypothesis 2, compared with the competitive industry, the impact of mixed-ownership reform on the innovation activities is more significant in the monopoly industry.

The empirical results show an interesting finding. Although the mix-ownership reform aims to practice in the competitive industries, the innovation in monopoly industries has been improved too.

4.3. Macro-economic effects

4.3.1. Province-level policy

As an important policy to realize the institutional restructuring of SOEs, the effect of the mix ownership reform will be affected by the macroeconomic factors undoubtedly. In order to obtain the influence of macroeconomic variables, the regressions are as follows.

\[ Y_{it} = \beta_0 + \beta_1 K_{i,t} + \beta_2 K_{i,t} \cdot Post_t + \alpha X_{i,t} + \varepsilon_{i,t} \]  

(2)
where $Y_{i,t}$ is the corporate R&D investment, $K_{i,t}$ is the macroeconomic variables, including house price ($HousePR$), private sector ($PrivateSector$), credit ($PrivateCredit$) and equity finance ($MarketCap$). Among them, we use the local province’s housing prices growth to represent $HousHR$, use the ratio of employees in private and individual companies and employees in local provinces to represent $PrivateSector$, use the ratio of loan balance and GDP in the local province to measure $PrivateCredit$, and use the ratio of total market value of local listed companies and local GDP to catch $MarketCap$ respectively.

Post is the time dummy variable, which equals 1 when it is after 2013. $X_{i,t}$ is a series of control variables, which contains the educational expenditure ($Education$), the R&D expenditure ($Science&Technology$), and the degree of economic development ($AvrGDP$).

4.3.2. 2SLS estimation for macro-economic effect

In this section, we further use 2SLS estimation to consider the endogenous concern. We take the density of regional highway as the instrumental variable of per capita GDP (Liu & Zhou, 2014), and use the 2SLS method to estimate the effect of macroeconomic environment.

Table 9 reports the estimate results. Private credit and equity finance have significantly positive impact on corporate innovation input. The coefficient of the interaction of credit still negative but the significance decreases to 10% which is consistent with Lin, Lin, and Song (2010) but the effect is reducing. From the 2nd stage regression of these two variables, the coefficients of $PrivateCredit^*Post$ and $MarketCap^*Post$ are not significant, which implies that the conclusions on these two factors are robust.

What’s more, the coefficients of regional education expenditure and economic development are significantly positive, indicating that the increasing in regional education spending and develop regional economic will improve corporate innovation activities by

Table 8

| R&D               | RD_TA | RD_TA | RD_TA | RD_TA |
|-------------------|-------|-------|-------|-------|
| $HousePR$         | 0.002 | (0.004) |  |  |
| $HousePR^*Post$   | $-0.001$ | (0.007) |  |  |
| $PrivateSector$   | 0.003 | (0.023) |  |  |
| $PrivateSector^*Post$ | $-0.004$ | (0.001) |  |  |
| $PrivateCredit$   | 0.001 | (0.000) |  |  |
| $PrivateCredit^*Post$ | $-0.019$ | (0.000) |  |  |
| $MarketCap$       | 0.008 | (0.005) |  |  |
| $MarketCap^*Post$ | $-0.010$ | (0.012) |  |  |
| $Education$       | 0.098 | (0.019) |  |  |
|                   | 0.061 | (0.020) |  |  |
|                   | 0.095 | (0.018) |  |  |
|                   | 0.097 | (0.018) |  |  |
| $Science&Technology$ | 0.083 | (0.067) |  |  |
|                   | 0.018 | (0.064) |  |  |
|                   | 0.069 | (0.062) |  |  |
|                   | 0.078 | (0.062) |  |  |
| $AvrGDP$          | 0.024 | (0.003) |  |  |
|                   | 0.033 | (0.006) |  |  |
|                   | 0.025 | (0.002) |  |  |
|                   | 0.024 | (0.002) |  |  |
| $Constant$        | $-0.258$ | (0.027) |  |  |
|                   | $-0.352$ | (0.050) |  |  |
|                   | $-0.274$ | (0.021) |  |  |
|                   | $-0.259$ | (0.021) |  |  |
| $Firm FE$         | Yes   | Yes   | Yes   | Yes  |
| $N$               | 3269  | 3269  | 3269  | 3269  |
| $Adj-R^2$         | 0.698 | 0.700 | 0.699 | 0.698 |

Notes: $***p < 1\%, **p < 5\%, *p < 10\%$. Since investment is one of the key obstacles of local government, we focus on this explanatory variable in this subsection.
enhancing the enthusiasm of corporate innovation. Corporate R&D investment increases fast with a high motivation to innovate. This result is also consistent with the results of regional analysis. The impact of the mixed-ownership reform is higher in eastern region, whose economic is more developed.

4.4. Individual effects from the reform

4.4.1. Individual initial time

We further identify the effect from this reform on SOEs’ innovation, using the following regression,

$$ Y_{it} = \beta_0 + \beta_1 Post_{it} + \gamma_{Mix_{it}} \times Post_{it} + \alpha X_{it} + \epsilon_{it} $$

(3)

where the treatment group is the SOEs experiencing the reform, and the control group is the SOEs who do not experience the reform. Mix is a dummy variable which equals 1 if it was in the list of mixed reformed enterprises, otherwise is 0. We use three different events to identify mixed-ownership reform. First, using the year of 2013 to be the beginning of this reform as in the former sections. Second, we use the first time state ownership dropped down after 2013. The third, the time that the SOE published their mixed-ownership reform announcements.

Table 10 reports the regression results of those three events. We use the year of 2013 to be the shock, Post2013 equals 1 after 2013, otherwise is 0. Panel A shows that both the R&D input and output are increased after 2013, as the coefficients of Post2013 are significantly positive in column (1) and column (3). We can see that the R&D input increased 0.2% for SOEs after 2013 with intervention patents increasing 5.42 in average. Those SOEs mix-owned even increased extra 0.7% after the reform compared to those non-mixed SOEs. Panel B further checked the effect from decrease of the state ownership, which means the improvement of R&D input does come from the decrease of state ownership. We also find that R&D input increased thereafter. But the interactions are not significant in Panel B and Panel C. We use the individual date that the SOE announced its plan of mixed-ownership reform. The coefficients are not significant which means the effect from this reform may not come from individual firm but the beginning announcement on the total SOEs, which consistent with prospect theory (Barberis, Mukherjee, & Wang, 2016). These results imply that the ongoing mixed-ownership reform is helpful to improve SOEs R&D input because of state ownership’s decrease.

4.4.2. Individual mixed direction

As a brand-new reform, this reform is not only a mixture from SOEs to POEs, but also happens from POEs to SOEs. Therefore, we
further check the impact from the latter direction, using the empirical model as follows,

\[ Y_{it} = \beta_0 + \beta_1 \text{Post}_{i,t} + \gamma_1 \text{MixPOE}_{i,t} \times \text{Post}_{i,t} + \alpha X_{i,t} + \epsilon_{i,t} \]  

(4)

where the treatment group is the POEs experiencing the reform, and the control group is the POEs who do not experience the reform. \text{MixPOE} is a dummy which equals 1 if it has been mix-reformed, otherwise is 0. Consistent with the results of Table 10, we use the year of 2013 to identify \text{Post}.

Table 11 reports the regression results. The coefficient of \text{Post} is significant, which means the POEs decreased their R&D input by 0.3% in average, which is consistent with Shi and Zhang (2018). The impact from the mixed-ownership reform is identified by the interaction item, \text{MixPOE*Post}, which is 0.010. This means those POEs mix-owned increase R&D by 1% higher than those POEs non-reformed. This result also implies that China’s mixed-ownership reform not only improves SOEs’ R&D but also significantly improves POE’s R&D input.8

8 The coefficients of \text{Post} and \text{MixPOE*Post} are not significant for patent, because the effect on patents may not appear in a short run. Further, it will need a longer period to track on patents.

### Table 10

Individual effects from the reform: individual initial time.

| Panel A. Policy announcement as the shock |
|------------------------------------------|
| Variables | (1) | (2) | (3) | (4) |
| RD_TA | Patent | Patent1 | Patent2 |
| Post2013 | 0.002*** | 6.780 | 5.418** |
| (0.001) | (6.090) | (2.592) | (4.082) |
| Mix*Post2013 | 0.007*** | 17.862 | 11.889 |
| (0.001) | (20.437) | (10.742) | (10.058) |
| Control variables | Controlled | Controlled | Controlled |
| Province | Clustered | Clustered | Clustered |
| Observations | 1,869 | 1,869 | 1,869 |
| Number of firm | 387 | 387 | 387 |
| Adjusted R-squared | 0.109 | 0.010 | 0.020 |
| | | | -0.000 |

| Panel B. Decrease in state ownership as the shock |
|------------------------------------------|
| Variables | (1) | (2) | (3) | (4) |
| RD_TA | Patent | Patent1 | Patent2 |
| PostState | 0.002*** | 14.575 | 8.280 |
| (0.001) | (20.978) | (11.914) | (9.399) |
| Mix* PostState | -0.004* | -19.553 | -9.397 |
| (0.002) | (21.865) | (13.008) | (9.913) |
| Control variables | Controlled | Controlled | Controlled |
| Province | Clustered | Clustered | Clustered |
| Observations | 1,869 | 1,869 | 1,869 |
| Number of firm | 387 | 387 | 387 |
| Adjusted R-squared | 0.016 | 0.008 | 0.015 |
| | | | 0.000 |

| Panel C. Individual announcement as the shock |
|------------------------------------------|
| Variables | (1) | (2) | (3) | (4) |
| RD_TA | Patent | Patent1 | Patent2 |
| PostAnnounce | 0.006 | 16.589 | -2.449 |
| (0.005) | (19.231) | (2.916) | (17.151) |
| Mix* PostAnnounce | 0.000 | 0.000 | 0.000 |
| (0.000) | (0.000) | (0.000) |
| Control variables | Controlled | Controlled | Controlled |
| Province | Clustered | Clustered | Clustered |
| Observations | 1,869 | 1,869 | 1,869 |
| Number of firm | 387 | 387 | 387 |
| Adjusted R-squared | 0.016 | 0.008 | 0.015 |
| | | | 0.001 |

This table consider different beginning of the reform. Panel A uses the year of 2013. Panel B uses the decrease of state-owned block after 2013. Panel C uses the announcement of individual firms.

Notes: ***p < 1%, **p < 5%, *p < 10%.
5. Robustness check

We also choose some alternative measure to improve the robustness of empirical results. On the one hand, we use GDP growth rate to measure the degree of economic development, instead of using per capita GDP. On the other hand, we add a new instrumental variable to replace the density of highway.

5.1. GDP growth

Table 12 reports the results. The coefficient of house price in column (1) is significantly negative, indicating that the more investment in the real estate will lead to the less corporate R&D investment, and the mixed-ownership reform could alleviate the negative impact of housing prices (the coefficient of interaction is significantly positive). According to the coefficient of private sector and of interaction in column (2), we find that the proportion of private sector has a significant positive correlation with firm R&D investment. With the boost of the mixed-ownership reform, the marginal impact of private sector on corporate R&D investment will weaken.

The coefficients of interactions in column (3) and column (4) also show that credit and equity financing have a significant positive impact on corporate R&D investment. The reason is that companies could obtain more funds for corporate R&D investments through credit and equity financing after reform, especially through equity financing (the coefficient of interaction is larger in column (4)). Consequently, the R&D investment will increase significantly.

Moreover, we can also see the significance of economic development, as the coefficients of GDP growth are significantly positive. The coefficients of regional education expenditure are still significantly positive, indicating that the increasing in regional education spending will improve corporate innovation activities.
5.2. Instrumental variable

Following Liu and Zhou (2014), we use the natural logarithm of the highway to replace the density of highway, and do the robustness check. We find the initial result of 2SLS estimation is still robust. The result is shown in Table 13. What’s more, the result still robust when we control the secondary industry fixed effect.

6. Conclusions

Based on the data of Chinese A-share listed manufacturing firms, we analyze the impact of mixed-ownership reform on corporate innovation capability by DiD approach. The innovation activities of enterprises are composed of innovation input and innovation output, which are measured by R&D investment and patents respectively. We find that mixed-ownership reform plays an active role in corporate innovation, not only by increasing R&D investment, but also by increasing the number of all patent applying and invention patent applying. Moreover, we examine the influence of unbalanced regional economic development and industrial monopoly protectionism on the reform efficiency. This paper shows that the impact of mixed-ownership reform on innovation is more pronounced in monopoly industries than in competitive industries although the reform is announced to only focus on competitive industries. Compared with the other regions, the impact on innovation capacity is improved higher in the eastern region.

This study continued to answer the question whether China’s state-sector reform increase corporate efficiency, and confirm the benefit of mixed-ownership reform on corporate innovation. What’s more, inspired by other field’s empirical works, this paper finds the heterogeneities of policy effect from industries, regions and macroeconomic environment. We also identify the initial time of this reform for individual firms, finding that the effect is significant from the decrease of state ownership. From the other direction of this reform, we further check the POEs practicing this mixed-ownership reform, which are also improved their R&D input significantly. Therefore, our paper contributes on providing evidence that China’s ongoing mixed-ownership reform does improve firms’ innovation for both SOEs and POEs.

Acknowledgements

This paper has benefited from comments and suggestions from Justin Yifu Lin, Colin Xu, Ming Lu, Zhangkai Huang, Hao Wang, Kewei Hou, Qian Sun, Lifeng Dong, Huihua Nie, Ruiming Liu and the discussants at 2016 International Conference of New Structural Economics (Peking University), 2018 Conference on China’s Reform and Opening Up: Economic Development and Structural Change, 2018 Guanghua International Symposium on Finance, 2019 Conference on Financial Technology and Finance Development in China.
Table 13
Robustness test: alternative instrument variable.

| Variable      | 1st stage | 2nd stage | 1st stage | 2nd stage | 1st stage | 2nd stage | 1st stage | 2nd stage |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| HousPR        | −0.718*** | −0.005 (0.056) | 3.075*** | 0.067 (0.040) | 0.019 (0.000) | 0.014*** (0.000) |
| PrivateSector | 1.392*** (0.053) | 0.0103 (0.010) | 0.032*** (0.002) | −0.003*** (0.001) |
| PrivateCredit | 0 (0.000) | 0 (0.000) | 0 (0.000) | 0 (0.000) |
| MarketCap     | 0.002 (0.002) | 0.008** (0.004) | −0.004 (0.005) | −0.007 (0.013) |
| DensityHighway| 0.379** (0.191) | 0.097*** (0.020) | 0.979*** (0.063) | 0.084*** (0.028) |
| AvrGDP        | 7.028*** (0.452) | 0.141 (0.071) | 1.485*** (0.191) | 0.055 (0.067) |
| Education     | 0.207*** (0.035) | 0.069*** (0.010) | 0.384*** (0.039) | 0.389*** (0.049) |
| Science&Technology | 0.016*** (0.005) | 0.014 (0.013) | 0.027*** (0.004) | 0.022*** (0.003) |
| Constant      | 9.023*** (0.327) | −0.203*** (0.049) | 7.627*** (0.067) | −0.207*** (0.107) |
| Firm FE       | Yes | Yes | Yes | Yes |
| N             | 3,269 | 3,269 | 3,269 | 3,269 |
| Adj-R²        | 0.975 | 0.758 | 0.996 | 0.759 |

Notes: ***p < 1%, **p < 5%, *p < 10%.

and 2020 AEA Annual Meeting for comments on Zhang’s related papers. We acknowledge the financial support from the Ministry of Education’s Major Project (Grant No. 14JJD790010) and the National Natural Science Foundation of China (Grant No. 71472167). Jinlong Huang, Shixian Lv and Zhiwei Wang provided excellent research assistance during data collection on firm’s announcements.

Appendix A. Variable definition and calculation

| Variable         | Definition | Data Source |
|------------------|------------|-------------|
| RD_TA            | The ratio of R&D expenses and total asset | Wind CFD |
| Patent           | The number of total patent applications | CSMAR and SIPO |
| Patent1          | The number of invention patent applications | CSMAR and SIPO |
| Patent23         | The number of utility patent and design patent applications | CSMAR and SIPO |
| SOE              | Equals 1 when it is a SOE and equals 0 when it is a POE | Wind Database |
| Leverage         | Total debt over total asset | Wind CFD |
| ROE              | Rate of Return on Common Stockholders' Equity | Wind CFD |
| SalesGrowth      | Business's increasing rate of income | Wind CFD |
| Size             | The logarithm of total assets | Wind CFD |
| Liquidity        | The ratio of liquidity asset and total asset | Wind CFD |
| Labor            | The logarithm of total employees | Wind CFD |
| Tangibility      | The ratio of tangible asset and total asset | Wind CFD |
| MB               | Market-book ratio | Wind CFD |
| HiTechIndustry   | Dummy variable, which equals 1 when it belongs to high-tech industry and equals 0 when belongs to non-high-tech industry | Wind CFD |
| HousPR           | The local province’s housing prices growth | NBS (China) |
| PrivateSector    | The ratio of employees in private and individual companies and total employee in local province | NBS (China) |
| PrivateCredit    | The ratio of loan balance and GDP in the local province | Wind CFD and NBS (China) |
| MarketCap        | The ratio of the sum of listed companies’ market values and GDP in the local province | Wind CFD and NBS (China) |
| Education        | The ratio of educational expenditure over total expenditure in the local province | NBS (China) |
| Science&Technology | The ratio of educational over total expenditure in local province | NBS (China) |
| AvrGDP           | Ln(Per Capita GDP) | NBS (China) |
Appendix B. Tests for PSM matching sample

| Sample       | Mean  | Standard deviation (%) |
|--------------|-------|------------------------|
|              | SOEs  | POEs                   |
| Leverage     |       |                        |
| Unmatch      | 0.518 | 0.460                  | 32.5 |
| Match        | 0.512 | 0.500                  | 6.6  |
| ROE          |       |                        |
| Unmatch      | 0.080 | 0.078                  | 2.1  |
| Match        | 0.079 | 0.091                  | −9.3 |
| SalesGrowth  |       |                        |
| Unmatch      | 0.181 | 0.176                  | 2.1  |
| Match        | 0.181 | 0.204                  | −9.1 |
| Size         |       |                        |
| Unmatch      | 8.402 | 7.720                  | 60.2 |
| Match        | 8.245 | 8.273                  | −2.5 |

* NBS (China): National Bureau of Statistics of the People’s Republic of China.

References

Aghion, P., Van Reenen, J., & Zingales, L. (2013). Innovation and institutional ownership. *American Economic Review, 103*(1), 277–304.

Alen, F., Lin, J., & Qian, M. (2005). Law, finance, and economic growth. In China. *Financial Economics, 77*(1), 57–116.

Audretsch, D. B., & Feldman, M. P. (1996). R&D spillovers and the geography of innovation and production. *American Economic Review, 86*(3), 630–640.

Bertrand, M., & Mullainathan, S. (2003). Enjoying the quiet life? Corporate governance and managerial preferences. *Journal of Political Economy, 111*(5), 1043–1075.

Boubakri, N., El Ghoul, S., Guedhami, O., & Megginson, W. (2018). The market value of government ownership. *Journal of Corporate Finance, 50*, 44–65.

Brandt, L., Van Biesebroeck, J., Wang, L., & Zhang, Y. (2017). WTO accession and performance of Chinese manufacturing firms. *American Economic Review, 107*(9), 2784–2820.

Brav, A., Jiang, W., Ma, S., & Tian, X. (2018). How does hedge fund activism reshape corporate innovation? *Journal of Financial Economics, 130*(2), 237–264.

Che, J., & Qian, Y. (1998). Insecure property rights and government ownership of firms. *Quarterly Journal of Economics, 113*(2), 467–496.

Chen, R., El Ghoul, S., Guedhami, O., & Nash, R. (2018). State ownership and corporate cash holdings. *Journal of Financial and Quantitative Analysis, 53*(5), 2293–2334.

Chen, R., El Ghoul, S., Guedhami, O., & Wang, H. (2017). Do state and foreign ownership affect investment efficiency? Evidence from privatizations. *Journal of Corporate Finance, 42*(1), 408–421.

Crouzet, N., & Eberly, J. (2019). Understanding weak capital investment: The role of market concentration and intangibles. *NBER working paper No.25869.*

Cull, R., & Xu, L. C. (2005). Institutions, ownership, and finance: The determinants of profit reinvestment among Chinese firms. *Journal of Financial Economics, 77*(1), 117–146.

D’Souza, J., & Nash, R. (2017). Private benefits of public control: Evidence of political and economic benefits of state ownership. *Journal of Corporate Finance, 46*, 232–247.

Fan, J. P. H., Huang, J., Morck, R., & Yeung, B. (2017). Institutional determinants of vertical integration in China. *Journal of Corporate Finance, 44*, 524–539.

Fan, J. P. H., Wang, T. J., & Zhang, T. (2007). Politically connected CEOs, corporate governance and post-IPO performance of China’s partially privatized firms. *Journal of Financial Economics, 84*(2), 330–357.

Fan, J., Gao, Y., & Xu, C. (2018). Decentralized privatization and change of control rights in China. *The Review of Financial Studies, 31*(10), 3854–3894.

Gao, H., Hsu, P. H., & Li, K. (2018). Innovation strategy of private firms. *Journal of Financial and Quantitative Analysis, 53*(1), 1–32.

Gu, L. (2016). Product market competition, R&D investment, and stock returns. *Journal of Financial Economics, 119*(2), 441–455.

Guariglia, A. (2008). Internal financial constraints, external financial constraints, and investment choice: Evidence from a panel of UK firms. *Journal of Banking & Finance, 32*(9), 1795–1809.

Gutiérrez, G., & Philippon, T. (2017). Declining competition and investment in the US. *NBER working paper No.23583.*

Hao, Y., & Lu, J. (2018). The impact of government intervention on corporate investment allocations and efficiency: Evidence from China. *Financial Management, 47*(2), 343–419 Summer.

Hovakimian, G. (2009). Determinants of investment cash flow sensitivity. *Financial Management, 38*(1), 161–183.

Huang, K. G. (2010). China’s innovation landscape. *Science, 329*(5992), 632–633.

Huang, Z., Li, L., Ma, G., & Xu, L. C. (2017). Hayek, local information, and commanding heights: Decentralizing state-owned enterprises in China. *American Economic Review, 107*(8), 2455–2478.

IMF (2017). People’s Republic of China: 2017 Article IV consultation. *IMF country report No.17/247.*

Jia, N., & Tian, X. (2018). Accessibility and materialization of firm innovation. *Journal of Corporate Finance, 48*, 515–541.

Lin, J., Lin, P., & Song, F. (2016). Property rights protection and corporate R&D: Evidence from China. *Journal of Development Economics, 119*(1), 49–62.

Liu, C., & Zhou, L. A. (2014). Highway construction and regional economic development: Evidence from Chinese county-level cities. *American Economic Science (in Chinese), 2*, 55–67.

Lu, Y., & Shi, X. (2012). Corporate governance reform and state ownership: Evidence from China. *Asia-Pacific Journal of Financial Studies, 41*(6), 665–685.

Megginson, W. (2017). Privatization, state capitalism, and state ownership in the 21st century. *Foundations and Trends in Finance, 11*, 1–153.

Megginson, W., Ullah, B., & Wei, Z. (2014). State ownership, soft-budget constraints, and cash holdings: Evidence from China’s privatized firms. *Journal of Banking & Finance, 48*, 276–291.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy, 98*(5), 71–102.
Rong, Z., Wang, W., & Gong, Q. (2016). Housing price appreciation, investment opportunity, and firm innovation: Evidence from China. *Journal of Housing Economics, 33*(3), 34–58.

Sampat, B. (2018). A survey of empirical evidence on patents and innovation. *NBER working paper, No. 25383*.

Sappington, D. E. M., & Stiglitz, J. E. (1987). Privatization, information and incentives. *Journal of Policy Analysis and Management, 6*(4), 567–582.

Schoenherr, D. (2019). Political connections and allocative distortions. *The Journal of Finance, 74*(2), 543–586.

Shang, Q., Poon, J. P. H., & Yue, Q. (2012). The role of regional knowledge spillovers on China’s innovation. *China Economic Review, 23*(4), 1164–1175.

Shi, J. C., & Zhang, X. Q. (2018). How to explain corporate investment heterogeneity in China’s new normal: Structural models with state-owned property rights. *China Economic Review, 50*(8), 1–16.

Shleifer, A. (1998). State versus private ownership. *Journal of Economic Perspectives, 12*(12), 133–150.

Shleifer, A., & Vishny, R. W. (1994). Politicians and firms. *Quarterly Journal of Economics, 109*(4), 995–1025.

Shleifer, A., & Vishny, R. W. (1997). A survey of corporate governance. *Journal of Finance, 52*(2), 737–783.

Song, H., & Zhang, M. (2017). Spatial spillovers of regional innovation: Evidence from Chinese provinces. *Emerging Markets Finance and Trade, 53*(9), 2104–2122.

Stein, J. C. (2003). Agency, information and corporate investment. *Handbook of the Economics of Finance, 1*, 111–165.

Tan, D., Cheng, C., Lei, M., & Zhao, Y. (2017). Spatial distributions and determinants of regional innovation in China: Evidence from Chinese metropolitan data. *Emerging Markets Finance and Trade, 53*(6), 1442–1454.

Tan, Y. X., Tian, X. D., & Zhao, H. L. (2015). *The real effects of privatisation: Evidence from China’s Split Share Structure Reform*. Social Science Electronic Publishing working paper.

Woo, W. T., Hai, W., Jin, Y., & Fan, G. (1994). How successful Chinese enterprise reform been? Pitfalls in opposite biases and focus. *Journal of Comparative Economics, 18*(3), 410–437.

Xu, C. (2011). The fundamental institutions of China’s reforms and development. *Journal of Economic Literature, 49*(4), 1076–1151.

Zhang, A., Zhang, Y., & Zhao, R. (2003). A study of the R&D efficiency and productivity of Chinese firms. *Journal of Comparative Economics, 31*(3), 444–464.

Zhang, X. Q. (2020). State ownership, intellectual property protection and M&A manipulation: Evidence from China’s mixed-ownership reform. *2020 AEA annual meeting*. 

X. Zhang, et al. *China Economic Review 61* (2020) 101450