



# China's R&D explosion—Analyzing productivity effects across ownership types and over time



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## ABSTRACT

In the past years, Chinese firms increased their spending on R&D substantially and worked on achieving a higher quality level of R&D. We analyze whether different R&D activities show a positive influence on total factor productivity (TFP) for firms of different ownership types and across two time periods. Our panel dataset with annual information allows us to study listed firms over the two time periods 2001–2006 and 2007–2011. Privately owned enterprises (POEs) not only obtain higher returns from own R&D than majority and minority state-owned enterprises (SOEs), they are also able to increase their leading position. Overall strong increases in the size of patent stocks are related to a decreasingly positive or even vanishing influence on TFP. POEs not only produce R&D of the highest quality but are also the only ownership type profiting from higher quality. Up to now research collaborations allow almost no benefit with the only exception stemming from domestic collaborations with individuals. Our comprehensive analysis depicts strengths but also weaknesses of the corporate sector in China. We derive implications for the further development of economic policies.

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## 1. Introduction

By now it has become consensus that a sustainable development of the Chinese economy is increasingly dependent on productivity gains instead of input factor accumulation. Unleashed by China's transition from a planned toward a mixed market economy, competition and privatization have contributed to total factor productivity (TFP) gains ever since (Brandt et al., 2012; Hsieh and Klenow, 2009). Throughout the past years, China's corporate sector has witnessed an unprecedented rise in R&D activities—observable by increases in R&D expenditures and patent applications of private and state-owned firms. Although the positive effect of R&D on productivity is well documented in the literature (e.g., Griliches and Mairesse, 1991 for developed economies, Hu, 2001 for China up to the 1990s), China's recent stunning surge in different R&D activities has not been investigated from this perspective.

In this study we analyze whether the rise in R&D activities shows a positive and sustained influence on productivity of Chinese firms. Our analysis focuses on differences between majority

and minority state ownership as well as private ownership and on differences in the impact of R&D activities throughout the time periods 2001–2006 and 2007–2011. We investigate different aspects of R&D activities to allow not only for increasing quantity but also for differences in the quality and technological sophistication of R&D, and we consider the effectiveness of collaborative research activities.

Before 2001, China's R&D expenditures were below 1% of its GDP but have since doubled to exceed 2% in 2013. While this ratio is slightly above the EU-28 level, China now takes the second rank behind the US in terms of total R&D investments. Similarly, patent applications have experienced a remarkable surge and reached more than 700,000 in 2013—making China's patent office (SIPO) the global leader in receiving national applications since 2011. Also in other legislations, such as Europe or the US, the Chinese share of patent applications increases strongly. However, so far it remains unclear whether China's rise in R&D activities corresponds to higher TFP. Critics claim that the enormously rising number of patent applications will only impact TFP growth if the economic value and technological sophistication of the underlying inventions is substantially improved (World Bank, 2012).

We address this issue by analyzing how R&D activities of the recent decade contribute to Chinese firms' productivity. Previous studies have examined the influence of R&D on productivity only

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until the late 1990s. In these years, however, research was predominantly carried out by a few state-owned firms. From the beginning of the 2000s, R&D investments not only increased strongly but also improved in quality. Furthermore, against the background of China's economic transition, a large number of minority state-owned and private-owned firms have joined China's innovation efforts and contributed vigorously to R&D activities of China's corporate sector. In this study we are therefore able to derive novel evidence for the productivity effects of R&D activities for state and non-state firms between 2001 and 2011. Since China's "Medium- to Long-term Plan for Science and Technology Development (2006–2020)" (MLP) has brought considerable changes to its innovation policy, we separately investigate the time periods before and after its implementation. With this background, we examine how heterogeneity in the volume, economic value, technological sophistication, and collaboration mechanisms of R&D activities influence the productivity of Chinese firms.

For our empirical analysis we compile a unique panel dataset that covers the population of Chinese firms listed at the stock exchanges of mainland China. For the operationalization of our main variables, we combine accounting data including information on R&D expenditures with national patent applications. Our R&D variables provide rich information about forward citations, the share of high-tech patents, and domestic as well as international R&D collaborations. To account for potential endogeneity issues in productivity estimations, we follow the methodology proposed by Levinsohn and Petrin (2003). In addition, we verify the robustness of our main results by applying, first, the approach of Olley and Pakes (1996) and, second, system GMM estimation.

We briefly foreshadow our findings. Privately owned enterprises (POEs) not only achieve higher returns from own R&D than majority and minority state-owned enterprises (SOEs), they are also able to increase their leading position. Thus, exposure to competition seems to be beneficial for the efficiency of these firms. Overall strong increases in the size of patent stocks are related to a decreasingly positive or even vanishing influence on TFP. This outcome could be a result of an economic policy that puts much more emphasis on quantity instead of quality. POEs not only achieve research of the highest quality but are also the only ownership type profiting from higher quality. Up to now research collaborations bestow almost no benefit with the only exception stemming from domestic collaborations with individuals. In the future, it may be possible to achieve better outcomes if increasing competition is leading firms to engage in collaborations that truly lead to knowledge gains and cost savings.

The remainder of this paper is structured as follows. Section 2 provides information on the institutional background, Section 3 discusses prior literature, and Section 4 explains our empirical method. We describe our data sources and our sample in Section 5 and present our results in Section 6. Section 7 derives implications and Section 8 concludes.

## 2. Institutional background

### 2.1. State-owned firms versus non-state sector

Beginning with China's "reform and opening" in 1978, the transition from a centrally-planned to a mixed-market economy has been paralleled by a shift of economic activities from the state to the non-state sector. Non-state-owned firms were allowed to enter a number of previously prohibited industries and operated in increasingly deregulated and competitive markets (Xu, 2011). While smaller non-state collectives in light industries mainly produced and sold consumer products at market prices, China's larger state-owned firms in heavy industries remained shielded from

competitors and sold capital goods according to a dual-price system (Zhu, 2012)<sup>1</sup>. Despite the introduction of modern management techniques which linked income to firm performance, the state sector's lack of competition, binding input and output quotas, and soft budget constraints facilitated a divergence in TFP growth between firms in the state and the non-state sector (Jefferson et al., 1996).

Throughout the second reform decade from 1988 to 1998, the government let the non-state sector grow but kept employment in the state sector constant in order to avoid social instability (Heilmann, 2008). State-owned firms were still obliged to sell a share of their products below market prizes but were protected from looming bankruptcy with preferential access to credit (Holz, 2003, p. 75). In contrast, firms in the non-state sector were facing hard budget constraints for investment and had to excel against a growing number of entrants started by entrepreneurs or emanating from restructured state entities and foreign-invested firms (Naughton, 2007, p. 309). As a result, TFP growth in the domestic non-state sector remained above the growth rate of the state sector (Jefferson et al., 2000).

Since 1998, deep structural transformation accelerated the privatization of former state-owned firms and, subsequently, the establishment of private firms has become formally legalized (Zhu, 2012). Throughout the late 1990s and early 2000s, many state-owned firms and collectives were closed or privatized (Yusuf et al., 2006, p. 86). When measured by either the number of firms or share in industrial gross output, the state sector has considerably lost in economic importance. For instance, the contribution of state-owned firms to gross industrial output has decreased from above 70% in the early 1990s to around 20% in 2001 and has reached 8% in 2012 (NBS, 2014).

However, even after 30 years of reforms, the socialist legacy is still apparent at state-owned firms, for example through higher levels of capital accumulation, preferential access to financial resources, profits from monopoly rights in a number of industries<sup>2</sup>, and protection from foreign competition (Zhu, 2012; Branstetter and Feenstra, 2002; Amiti and Javorcik, 2008). Excessive labor from the shrinking state sector has been partially absorbed by the non-state sector. In addition, non-state firms have benefited from rural–urban migration and demographic trends which, until recently, have contributed to a surplus of Chinese labor that kept wages competitively low. Reflected in differences in factor endowment, production in the state sector remains more capital intensive whereas production in the non-state sector is more labor intensive.

Following the latest wave of structural reforms and China's accession to the World Trade Organization (WTO) in 2001, the possibility of bankruptcy for unprofitable firms in the state sector, and the reduction of excessive labor ultimately contributed to enormous TFP gains. For the years 1998 to 2007, Zhu (2012) reports an annual average TFP growth rate of 5.50% for the state sector which, for the first time since the 1978 reforms, has outpaced the growth rate in the non-state sector (3.67%). These trends are confirmed by Jefferson et al. (2008) who examine multi-factor productivity by ownership type throughout the time period 1998 to 2005 and report a growth rate of 15.63% for the state sector—roughly twice as high as in the non-state sector.

While there is conflicting evidence for China's overall TFP growth rate and the contribution of TFP to output (see Tian and Yu, 2012 for a meta-analysis), recent studies have investigated drivers of TFP at the firm level and have pointed out that a significant

<sup>1</sup> The dual price system is characterized by the coexistence of prices fixed by the government for a selection of high-priority goods with prices allowed to adjust according to supply and demand for an increasing share of remaining products.

<sup>2</sup> These industries include energy, transportation, telecommunication, banking, entertainment, education, and health care.

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