Research Policy xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

The allocation and effectiveness of China's R&D subsidies - Evidence from listed firms

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ARTICLE INFO

Article history:
Received 11 November 2014
Received in revised form 16 May 2016
Accepted 17 May 2016
Available online xxx

JEL classification:
O38
O32

Keywords:
China
R&D subsidies
Economic transition
Propensity score matching
Conditional difference-in-differences

ABSTRACT

In this study we investigate the allocation of China's R&D subsidies and their effectiveness in stimulating business R&D investments for the population of Chinese listed firms between 2001 and 2006. With respect to subsidy allocation, we find that firm selection is mainly determined by prior grants, high quality inventions, and minority state-ownership. Market-oriented provincial governments distribute grants less frequently, and firms located in developed provinces receive grants more often. Considering effectiveness, R&D subsidies instantaneously crowd-out business R&D investment but are neutral in later periods. In 2006, one public RMB reduces business R&D investments by half an RMB. However, crowding-out is not prevalent for repeated recipients of R&D subsidies, high-tech firms, and minority state-owned firms.

1. Introduction

In global comparison, China's business expenditures for R&D and the economy's total R&D spending both rank second to the US (OECD, 2014). Currently China contributes 20% of the global R&D expenditures and, assuming linear growth, will replace the US before 2020 to become the single largest contributor to global R&D spending. Within one decade, China has closed the gap with high income countries in terms of R&D. Given China's formerly planned economy, an obvious question is to what extent China's stunning rise as an innovation-driven economy has been influenced by governmental economic policies.

To provide an answer, we focus on the crucial time period at the onset of the millennium, when the State Council sought to encourage China's economic development through innovation, high-technology, and industrialization (Liu et al., 2011). R&D operations have been largely relocated from public research institutes to state and non-state firms to increase China's industrial R&D and to contribute to the economy's technological sovereignty (Liu, 2009a). Importantly, the government provided substantial funding in the form of R&D grants to incentivize firms' R&D. In particular, these subsidies have targeted inventive high-tech firms, firms intended to become main drivers of China's technological trajectory.

From 2001–2006, China's public support for industrial innovation amounted to 450 billion RMB – two thirds of which came from R&D funds – and contributed 60% of all industrial R&D investments (Ministry of Finance (MOF) various years). Over the same period, the industrial contribution to China's gross expenditures for R&D increased from 60% to 71% and extended their contribution to GDP from 0.58% to 0.99%. Likewise, gross R&D expenditures to GDP grew from 0.95% to 1.39% (MOF various years, National Bureau of Statistics (NBS) various years).

Although these figures show increasing industrial R&D in relative and absolute terms, the effect of China's R&D subsidies remains unclear. As pointed out by Arrow (1962), due to market failure in the production of knowledge, R&D investments of firms may remain below the social optimum and require correction by public subsidies. However, if government subsidies fail to increase firms' own R&D investments, i.e. R&D investments financed by firms' own funds, then the economic justification for public funding of business R&D is questionable. In other words, if grants allocated by the government do not result in additionality but instead are effectively neutral or even crowd-out firms' own R&D expenditures, the policy intervention cannot be considered a success. In China's case, the recurrent underachievement of national R&D targets throughout the first half of the last decade indeed questions the effectiveness of

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http://dx.doi.org/10.1016/j.respol.2016.05.007
0048-7333/

policy measures employed.[1] Thus, careful examination of the effectiveness of China's R&D subsidies on firms' own R&D expenditures is required.

Because prior studies of China's R&D subsidies are small in number and often suffer from methodological limitations, we aim to contribute new evidence to the literature. We estimate the effect of R&D subsidies by investigating changes in recipients' and otherwise comparable non-recipients' R&D investments over time. To estimate treatment effects and to control for potential selection bias in the distribution of grants, we derive robust estimates by combining non-parametric propensity-score matching (PSM) with a difference-in-differences (DID) estimator as the properties of both estimators are complementary.

This econometric strategy is employed to a unique panel on the population of Chinese listed firms, observed throughout the time period 2001–2006. We match firm level data from annual reports with numerous data sources, including patent data from the European Patent Office's Worldwide Patent Statistical Database (PATSTAT), and we match export data from Chinese Customs. An exhaustive set of variables is operationalized to capture the firm characteristics that determine the allocation of R&D subsidies. Because the government emphasized the importance of firms' inventiveness and high-tech orientation to accelerate China's technological trajectory, we place particular emphasis on these characteristics.

We briefly foreshadow our findings. For the allocation of R&D subsidies, our results show that the selection of recipient firms is mainly determined by high quality inventions whereas high-tech sector affiliation is less important. Further, we find that firms show persistence in receiving R&D subsidies. We also consider the consequences of China's transition from a centrally planned to a mixed market economy on grant distribution which, until now, have not been studied in the literature. Regarding the influence of state-ownership, we find that minority state-owned firms are more likely to become subsidy recipients than majority state-owned and private-owned firms. Provincial variation in China's transition towards a market-driven economy reveals that R&D subsidies are less often distributed by more market-oriented provincial governments and that China's national innovation policy of "picking the winners" is more supportive to firms located in developed provinces.

Considering effectiveness, we find that R&D subsidies instantaneously crowd-out firms' own R&D investment but are neutral in later periods. For example, in 2006 one public RMB reduced firms' own R&D investments by half an RMB. This implies that public subsidies fail to correct business R&D towards the social optimum but instead cause partial crowding-out. However, for repeated recipients, high-tech firms, and minority state-owned firms, we identify neutral effects, i.e. firms' own R&D investments remain unchanged. Nonetheless, the economic justification for China's R&D programs between 2001 and 2006 is generally questionable as we fail to identify additionality effects.

The remainder of this study is structured as follows. In Section 2 we discuss the rational for R&D subsidies, review prior studies and derive consequences of China's institutional structure for the allocation and effectiveness of R&D subsidies. In Section 3 we explain the econometric methodology employed. Section 4 introduces the data and provides descriptive statistics. Section 5 contains the main results, robustness tests, and further investigations. We provide concluding remarks in the final section.

[1] China's 9th and 10th "Science and Technology Development Plan" specify target ratios of 1.5% for gross R&D expenditures to GDP in 2000 and 2005 but actual ratios reached were 0.90% and 1.35%.

2. Previous literature

The seminal studies by Arrow (1962) and Nelson (1959) provide the theoretical rationale for R&D subsidies: because externalities in the production of knowledge are difficult to appropriate, social and private returns to inventive activity differ. In combination with the risk and moral hazard involved in financing R&D, this difference in returns may result in systematic underinvestment in R&D. To avoid the suppression of economic growth through sub-optimal innovation rates, correction of business R&D by public subsidies is required.

Although this argument has been widely accepted by researchers and policy makers, a simple reading might be misleading. First, the optimum growth rate of R&D in a given economy, industry, or firm is unknown and may differ over time (David, 2012). Second, it is difficult to identify those industries in which social returns exceed private returns on average (Hubbard, 2012) or those particular R&D projects for which social returns are negatively correlated with private returns (Trajtenberg, 2012). Third, as government failure in the selection of R&D projects may exceed market failure, neutral instead of targeted allocation of R&D grants might be preferable but is rarely found in practice (Foray, 2012). Recent contributions by Acemoglu et al. (2013) and Akcigit et al. (2014) attempt to address some of these issues in theoretical models as to provide more nuanced approaches for policy making.

The most critical question at the micro level is whether the government is able to select those R&D projects with high social returns that firms would not fund by themselves, due to low private returns. R&D subsidies encompass two main policy instruments: tax incentives and direct subsidies (David et al., 2000). The primary difference is that the former allow the firm to select R&D projects while the government remains neutral, whereas the latter typically are accompanied by government selection.

In our study we are concerned with the effect of direct R&D subsidies on firms' R&D investments. Precisely, we consider the effect of accumulated R&D grants received by a firm in a given year on changes in the firms' own R&D investments. Own R&D investments (net R&D investments) correspond to gross R&D investments less the R&D subsidies received. We illustrate the differences between gross and net R&D expenditures and the taxonomy of subsidy effects – ranging from crowding-out over neutrality to additionality – in Fig. 1.

Full crowding-out occurs when public funds are perfect substitutes for private funds and decrease firms' net R&D expenditure by the full amount of the R&D subsidy. Government failure, evident in the substitution of firms' own funds by public funds, occurs because it is unknown to the government whether the selected project would have been undertaken by the firm without support. To avoid crowding-out, in practice many R&D programs require that firms match public funds with private ones, e.g. one public USD with one private USD. However, even if the initiation of a firm's project was strictly conditional on the appropriation of public support and one-to-one matching of funds was demanded, the recipient may still readjust its portfolio of R&D projects and reallocate funds from dispensable projects to the publicly supported one. Thereby, the substitution of private funds for public funds is difficult to prevent as substitution takes place outside the supported project. Even though private funds released by R&D subsidies might be used totally for new R&D projects, i.e. the firms' net R&D investments remain generally unchanged, the firm may alternatively spend some these funds for non-R&D purposes—resulting in partial crowding-out.

The government's successful correction of market failure is achieved in the situation of additionality, that is, public grants are complementary to private funds and the net R&D expenditures of subsidized firms increase. This politically aspired outcome may

Please cite this article in press as: Boeing, P., The allocation and effectiveness of China's R&D subsidies - Evidence from listed firms. Res. Policy (2016), http://dx.doi.org/10.1016/j.respol.2016.05.007