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Do government grants promote innovation efficiency in China's high-tech industries?

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ABSTRACT

Despite extensive discussion about the important role of government in enterprise development, the function of government grants in the innovation activities of high-technology (high-tech) industries is still unclear. In this paper, the stochastic frontier model and a unique panel data set of 17 high-tech industries in China spanning the 2001–2011 period are applied to explore how government grants affect the innovation performance of these industries. Results indicate that the innovation efficiency of high-tech industries rapidly improved in the past decade. However, it is found that government grants exert a negative influence on innovation efficiency of high-tech industries. However, the impact of private R&D funding is significant and positive. Furthermore, when the high-tech industries are grouped into five sub-industries, the results show that government grants had different effects on the innovation in each sub-industry.

1. Introduction

High-tech industry is one of the most important industries in a knowledge-based economy. China's National and local governments are eager to develop the high-tech industry by investing substantial R&D grants in this sector. The objective of this paper is to investigate how government grants affect innovation efficiency in China's high-tech industry.

Chinese manufacturing industries have played a significant role in the development of China's economy since the implementation of the reform and opening-up policy. After three decade development, the Chinese government has realized that technology development and innovation are highly essential in the manufacturing industries. The government also emphasized that innovation is the driving force of economic growth and is the key factor to catch up with advanced industrial economies. These circumstances guided the Chinese government to formulate and promulgate a series of policies promoting high-technology (high-tech) industries. After years of development, China's high-tech industries accomplished considerable progress in innovation and technology development. Table 1 shows the development of China's high-tech industries from 2002 to 2011.

The economic literature on externalities indicates that innovation activities may lead to market failure (Arrow, 1962). In the national innovation system, the government plays an important role in assisting firms to enhance their competitiveness and innovation (Freeman, 1989; Lankhuizen and Woolthuis, 2004; Lundvall, 2010; Metcalfe, 1995; Nelson and Rosenberg, 1993; Patel and Pavitt, 1994; Porter, 2011; Watkins et al., 2015). However, the benefits of innovation, similar to those of public goods, are typically not completely extended to the private sector partly because innovation remains below the socially acceptable level. Consequently, governments attempt to address market failures through policy instruments, such as offering government grants. To date, many governments have already established grant-related mechanisms to promote R&D activities.

Since the 1980s, China has implemented the Torch Program for high-tech industrial development, and offered special policies and financial grants to enhance the development of high-tech industries. The Chinese government also promulgated several policies and laws to encourage enterprise R&D investment. Statistics show that the Chinese government spent approximately 60.17 billion Yuan during the past three decades to promote R&D activities. The total amount of government grants to high-tech industries has increased from 2.61 billion Yuan in 2002 to 11.59 billion Yuan in 2011, with an average annual growth rate of 34.41% (Fig. 1). Therefore, analyzing whether government grants result in positive externalities to simulate the innovation of high-tech industries in China is highly important.

This study aims to analyze the effects of government grants on the innovation of high-tech industries. According to the *China*

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Table 1
The development of high-tech industry from 2002 to 2011.

	2002	2005	2007	2009	2011
Number of enterprises (unit)	11,333	17,527	21,517	27,218	21,682
Annual average number of employed personnel (10 thousand persons)	424	663	843	958	1147
Revenue from principal business (100 million yuan)	14,614	33,922	49,714	59,567	87,527
Expenditure on R&D (100 million yuan)	187	362	545	892	1441
Patent application (piece)	5590	16,823	34,446	71,337	101,267

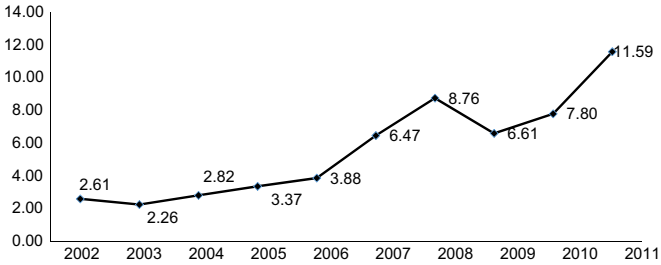

Fig. 1. The total of Government grants to high-tech industries in China from 2002 to 2011.

Statistics Yearbook on High Technology Industry, China's high-tech industrial sector is classified into five sub-sectors, namely (1) medicine, (2) aircraft and spacecraft, (3) electronic and communication equipment, (4) computer and office equipment, and (5) medical. Late on these five groups are further divided into two types of sub-industries based on R&D intensity. The reason for such division is to explore the difference in the effects of government grants on innovation. Furthermore, we investigate the effects of private R&D funding and other types of funding on industrial innovation, and estimate the innovation efficiency of high-tech industries in the past decade.

This study shows a positive effect of government grants on the innovation of high-tech industries. However, a significant difference was observed in the effect of grants on high-tech industries with different R&D intensity. To our knowledge, this issue has not been discussed in previous studies. Grants can promote the innovation efficiency in high-tech sub-industries with high R&D intensity; however, these grants can also exert a negative influence on high-tech sub-industries with low R&D intensity. Private R&D funding exerts a positive effect on the innovation of two types of high-tech sub-industries. The innovation efficiency of high-tech industries has enhanced rapidly in the past decade.

The remainder of this paper is structured as follows. Section 2 presents the literature review on government grants, private R&D funding, and industrial innovation. Section 3 describes our methodology and samples, including the variables used and data collection and processing. Section 4 discusses the results of this study. Further discussion about the implications of this study is reported in Section 5. Section 6 concludes the paper.

2. Literature review

Several studies focus on the effects of government grants on innovation. These government grants support firm innovation through various methods, such as tax preference, loans that stimulate innovation, subsidies on innovation activities, and government funding programs (Beugelsdijk and Cornet, 2002; Romijn and Albaladejo, 2002; Souitaris, 2002; Wallsten, 2000). Guan and Yam (2015) investigated the effects of Chinese government financial incentives on firms' innovation performance. These incentives include direct earmarks, special loans and tax credits. They find that special loans and tax credits affect firms' innovative performance positively while direct earmarks sometimes have negative effects. Hsu et al. (2009) investigated 127 government-funded projects in Taiwan and showed that government R&D funding alters the behavior of recipient firms and affects their innovation. Doh and Kim (2014) explored the impact of governmental support on the innovation of small and medium enterprises (SMEs) in South Korea, and the results indicate that government support had a positive relationship with industrial innovation. David et al. (2000) reviewed the literature on the relationship between R&D subsidies and R&D expenditure within different levels of aggregation. A few studies reported the effect of government subsidies on private R&D spending, financing, and innovation at the national level; however, the evidence is insufficient at the industry level. The current study measures the innovation efficiency in the Chinese context and analyzes the effect of government grants on industrial innovation. Another crucial aspect of this study is the discussion of the differences of the effects of grants on the innovation in the five sub-industries.

Several studies reported the effects of government grants on innovation; however, the findings of these studies are inconsistent because of differences in research objectives. Radas et al. (2015) investigated the effects of direct grants and tax incentives on recipient SMEs and the results suggest that direct subsidies used alone or with tax incentives strengthen the R&D orientation. Kang and Park (2012) studied the SMEs in South Korea's biotechnology industry and found that government R&D grants play a positive role in promoting innovation output; internal R&D human capital and internal R&D spending also have significant effects on innovation performance. Park (2015) analyzed the efficiency of government subsidy recipient, and found the efficiency of government subsidies among different recipients like university, laboratory and companies is different. Lichtenberg (1988) analyzed the relationship between federal contract and company R&D and concluded that government grants are not conducive to innovation output. Görg and Strobl (2007) and Wallsten (2000) investigated the relationship between government support for R&D and R&D expenditure. These researchers concluded that government grants may completely crowd out private R&D spending, and cast a negative effect on the firm's innovation. Yu (2013) revealed that the effect of government grants on innovation efficiency is insignificant from the regional perspective; these grants also have a negative effect on innovation at the regional level. By contrast, Guellec and Pottelsberghe (2003) quantified the effects of government grants on business R&D in 17 Organisation for Economic Co-operation and Development (OECD) member countries. These researchers concluded that government grants can reduce the cost of R&D activities for firms and generate further innovation by motivating additional private R&D spending. Branstetter and Sakakibara (2000) analyzed the effects of the Japanese government-sponsored research on firms by measuring the patenting performance of these firms. These researchers revealed that government sponsorship has a positive effect on innovation, which is particularly effective in basic research. Almus and Czarnitzki (2003) used a non-parametric matching approach to analyze the effects of public policy on the innovation activities of firms in eastern Germany. In comparison with firms without government subsidies, the innovation activities of government-sponsored firms increased by approximately 4%. Czarnitzki and Hussinger (2004) studied patenting performances of German firms to analyze the effects of government grants. Their conclusion shows that public R&D funding displays positive productivity effects.

Other studies discussed whether government grants will crowd

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