



Contents lists available at ScienceDirect

## International Review of Financial Analysis



## To what extent do financing constraints affect Chinese firms' innovation activities?

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## ARTICLE INFO

## Article history:

Received 15 May 2013

Received in revised form 30 November 2013

Accepted 7 January 2014

Available online xxx

## Keywords:

Financing constraints

Innovation activities

New products

Cash flow

## ABSTRACT

We investigate the extent to which financing constraints affect the innovation activities of over 120,000 mainly unlisted Chinese firms over the period 2000–2007. Based on a variety of specifications and estimation methods, we document that Chinese firms' innovation activities are constrained by the availability of internal finance. Specifically, private firms suffer the most, followed by foreign firms, while state-owned and collective enterprises are the least constrained. Moreover, the availability of internal finance represents a particularly binding constraint on the innovation activities of small firms, located in the coastal provinces, with low political affiliation, and fewer state shares, as well as for sole proprietorship firms.

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## 1. Introduction

Innovation is a central element in a large number of endogenous growth models and has been widely considered as a key driver of economic growth (Aghion & Howitt, 1992; Romer, 1990). One feature of innovation, its positive “spillovers”, suggests that its privately optimal level is lower than the optimal level from the point of view of the society. Given the high adjustment costs and uncertainty that characterize it, another key feature of innovation is that it is subject to binding financing constraints. This forces a gap between the cost of internal and external finance, which depresses innovation activities, and, consequently, restricts firm growth.

Due to its successful economic transition in the past three decades, China has become a major global participant. In this environment, its innovation system has undergone considerable changes and its innovation performance has improved remarkably. According to OECD reports (2009 and 2010), gross expenditure on R&D (GERD) in China increased consistently from 0.73% of GDP in 1991 to 1.5% in 2008. This growth is even more impressive considering that China's GDP has simultaneously grown by close to 9% per year on average, and can be seen as a consequence of the reforms in the education sector and the strengthening of the intellectual property rights legislation. The business sector's share of total R&D expenditure has also dramatically increased, from 30% in 1994 to 70% in 2008. Considering it is the second largest recipient of foreign direct investment (FDI) in the world (since 2004), China has become an attractive country for future R&D investment, and foreign companies have established hundreds of new R&D centers in the country in recent years. Furthermore, according to a

report of the Chinese Ministry of Commerce, China has become a large exporter of high-tech products, which accounted for 28.9% of its total exports in 2011.

However, China's innovation activities still face considerable challenges. Firstly, China strongly depends on foreign technology. In 2003, foreign-invested enterprises were responsible for 85.4% of China's total volume of high-tech exports.<sup>1</sup> As a result, Chinese firms lack core competitiveness and their economic returns are yet to be improved because of weak indigenous innovation capability. Moreover, R&D expenditure as a share of value added remains low in China compared to other countries. Chinese manufacturing sector's R&D expenditures made up only 1.9% of total value added in 2004, compared to 7–11% in France, Germany, Japan, Korea, the UK, and the US. In high-tech industries, this ratio in Chinese firms was only 4.6%, compared with around 20% in Korea and close to 30% in Japan, the UK, and the US. In addition, the share of total R&D expenditure allocated to basic research in China is small – only 6%, compared with 14% in both Korea and Russia, and 25% in both the United States and Europe.<sup>2</sup>

To promote the further development of innovation, and especially indigenous innovation, firms should increase their R&D expenditure, which can be achieved through government financial support. In 2006, the Chinese government put forward a policy called “The National Medium- and Long-Term Program of Science and Technology Development (2006–2020)”, which aimed at strengthening China's scientific and technological (S&T) progress, and achieve an innovation-oriented society by 2020. The most important aspects of this program can be

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<sup>1</sup> Source: National Research Center for Science and Technology for Development, *China Science and Technology Indicators 2004* (Beijing: Science and Technology Publication House, 2005).

<sup>2</sup> Source: “China High-Tech Industry Statistics 2006”, China Science and Technology Statistics (STS) website: <http://www.sts.org.cn/>.

summarized in three points. First, China committed to increasing its R&D expenditure relative to GDP ratio to 2.5% by 2020. Second, it committed to strengthening indigenous innovation, reducing dependence on foreign technology. Third, enterprises and the business sector would be the central driving force of the innovation process, instead of the Ministry of Science and Technology.<sup>3</sup>

Although this policy aims at generating positive incentives for Chinese firms' innovation activities, financial constraints have long been considered as the major obstacle for business innovation, especially in transition economies like China. Considering China's relatively poorly developed financial market and state-dominated financial system, we believe that capital and resources are possibly misallocated across firms owned by different agents. Specifically, state-owned enterprises (SOEs) get preferential support from the central government and state-dominated banks, finding it easier to obtain finance. However, this lending bias sets up political obstacles for private firms and prevents them from accessing external finance, despite their higher efficiency and faster growth. Huang (2003) describes this phenomenon as a "political pecking order" in the Chinese credit market.

In this paper, we aim at investigating the relationship between Chinese firms' innovation activities and the possible existence of financing constraints. We first assess the extent to which financing constraints affect Chinese firms' innovation activities, focusing on four ownership types: SOEs, foreign, private, and collective firms. Second, we test the extent to which firm heterogeneity in terms of firm size, location, political affiliation, percentage of state shares, and organization type is linked with financing constraints binding to different degrees.

We contribute to the literature along the following three dimensions. First, for the first time in the Chinese context, we test the extent to which financing constraints affect firms' innovation activities. Second, we estimate our regressions based on a very large database, compiled by the Chinese National Bureau of Statistics (NBS) over the period of 2000–2007. Our database is made up of 120,753 mainly unlisted firms from 31 provinces or province-equivalent municipal cities, which provide up to 745,548 firm-level observations. Third, we take into account various aspects of firm heterogeneity.

Based on a variety of different specifications and estimation methods, we document that Chinese firms' innovation activities are constrained by the availability of internal finance. Specifically, private firms suffer the most, followed by foreign firms, while SOEs and collective firms are the least financially constrained. Moreover, the availability of internal finance represents a particularly binding constraint for the innovation activities of small firms, located in the coastal areas, with low political affiliation, and fewer state shares. Last, joint-ventures are less likely to face financial constraints than sole proprietorship firms.

The remainder of the paper proceeds as follows. Section 2 reviews the literature on financing constraints and innovation activities. Section 3 introduces our database, and presents summary statistics. Section 4 puts forward our hypotheses. Section 5 illustrates our models and estimation methodology. Section 6 describes our main empirical results, while robustness tests are presented in Section 7. Section 8 concludes.

## 2. Literature review

### 2.1. Uniqueness of innovation activities

Compared with fixed investment, innovation activities have the following unique features. First, they are generally characterized by high adjustment costs. In practice, about 50% of innovation spending is made up of wages and salaries of research personnel, including highly skilled workers, educated scientists, engineers and other specialists. These types of employees are also characterized by substantial hiring,

firing and training costs (Hall & Lerner, 2010). Grabowski (1968) documents that the supply of research workers is not perfectly elastic. These workers cannot therefore be arbitrarily fired during downturns and subsequently rehired. Perhaps more importantly, other serious losses would emerge if fired specialists were rehired by the firm's competitors. Not only would the training spending become sunk, but also the rival would imitate inventions and benefit from the transmission of valuable knowledge (Himmelberg & Petersen, 1994). Pakes and Nitzan (1983) point out that firms which make original inventions should provide high wages for highly skilled workers to ensure their retention and avoid setting up a rival. Bernstein and Nadiri (1989) suggest that the marginal adjustment costs of R&D capital are consistently larger than those of physical investment for most industries. Similarly, Bernstein and Mohnen (1998) conclude that considerable adjustment costs exist in both the US and Japanese innovation intensive sectors.

The second important characteristic of innovation activity is its high degree of uncertainty, generating from its lack of collateral value, irreversibility, long-term returns, and market influence. According to Hall (1992), innovation patents, such as new designs and prototypes, cannot be easily used as collateral, because these innovation processes are likely to be firm-specific and their technology is still underdeveloped. Furthermore, the costs incurred to undertake innovation activities are normally entirely irreversible, since they are aimed at purchasing experiment-specific equipment and materials, and paying the wages of research personnel (Dixit & Pindyck, 1994). In addition, due to a series of processes characterizing R&D (investigation, preparation, incubation, illumination, verification and application), innovation activities are generally considered as long-term projects. Firms are uncertain about how much effort and materials are ultimately needed to complete each project (Pindyck, 1993). Finally, market demand or acceptance should also be considered as uncertain (Tyagi, 2006). Thus, based on this extreme uncertainty, external financiers, like banks and stock market investors, are reluctant to invest their funds in innovation projects.

### 2.2. Market inefficiencies in financing innovation

Innovation is very likely to suffer from market inefficiencies deriving from information asymmetry problems, as the firm carrying out innovation has more information than outside investors on the probability of success and the expected returns of its projects. Anton and Yao (2002) argue that firms are reluctant to fully reveal their potential innovation plans to avoid competitors' imitation. Moreover, accounting rules on R&D expenditure further contribute to information asymmetry (Aboody & Lev, 2000). This makes it hard for external investors to trace changeable information on the value of innovation.<sup>4</sup> Asymmetric information creates an imbalance of power in transactions, which leads to high costs of external financing. Thus, the lender would require higher returns due to the uncertainty of the borrower's payback capability. This implies that the supply and the demand of loans cannot reach equilibrium at the market interest rate. Additionally, the absence of organized innovation markets exacerbates the information asymmetries associated with innovation projects. Hence, the market price cannot fully reflect information on the value of innovation projects (Griliches, 1995).

Adverse selection occurs in financing innovation projects when borrowers and lenders suffer from asymmetric information problems. Since innovation ideas are not easily observed, outside lenders cannot know beforehand whether an innovation project is a cherry or a lemon.<sup>5</sup> Harhoff (1998) points out that this will force some potential investors to leave the innovation market due to high risk. In addition, loan size could be

<sup>4</sup> Since financial variables should be routinely reported in financial reports, outsiders are periodically informed about the changes in value of most tangible assets and physical investment. In contrast, R&D expenditures are generally charged to expense when incurred.

<sup>5</sup> A cherry usually indicates a high quality good, whereas a lemon denotes a poor quality good (Akerlof, 1970).

<sup>3</sup> See Table A1 in Appendix A for details on the implementation of this program.

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