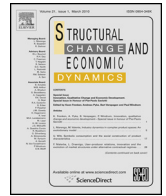




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Venture capital and innovation in China: The non-linear evidence

Jun Wen^a, Di Yang^a, Gen-Fu Feng^a, Minyi Dong^a, Chun-Ping Chang^{b,*}

^a School of Economics and Finance, Xi'an Jiaotong University, Shaanxi, China

^b Shih Chien University, Kaohsiung, Taiwan

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ABSTRACT

This study investigates the non-linear relationship between venture capital investment and technological innovation for 28 provinces in China, using the panel smooth transition regression (PSTR) model for the period 2001–2014. Our results confirm that the relationship within the empirical model is indeed non-linear, and venture capital (VC) only presents a positive impact on innovation in China when investment is large enough over the threshold level. However, VC may severely hurt the innovative abilities of invested enterprises when the scale of investment is relatively small, especially in “western” and “lower-investment” provinces after dividing the sample provinces into different groups.

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1. Introduction

The relationship between venture capital (VC hereafter) and technological innovation has attracted a lot of attention in the field of innovation theory, as the VC industry is an important part of capital markets and a significant driver of company operations. It also mainly contributes to a firm's innovation through financial support, value-added services, and monitoring and resource connections (Hellman and Puri, 2002; Hall and Lerner, 2010).¹ Kortum and Lerner (2000) as well as Faria and Barbosa (2014) stress that the development of VC mainly helps mitigate the financing constraint faced by start-up enterprises. Since these new companies are aware of the so-called brain drain (such as entrepreneurial talents, capabilities, and patents) by general investors, the emergence of VC effectively solves this problem by providing funds to innovative start-ups (Bottazzi and Da, 2002; Bertoni et al. 2010). In addition, as most VC investors are always closely involved in their invested enterprises, they thus not only closely monitor the firms' business

operations, but also provide huge valuable support, resource connections, and social networks to the investee, which exhibit the positive impact of VC on innovative performance (Hellmann and Puri, 2002; Arqué-Castells, 2012).

Potential costs do arise that are associated with VC, owing to the possibility of some institutional investors expropriating the wealth and innovative ideas of investee enterprises (Ueda, 2004; Atanasov, 2006; Dushnitsky and Lenox, 2006; Wadhwa et al., 2016). For example, VC has strong contract rights in controlling the firm's board, moving against ownership dilution, and directing future financing methods. Several research studies have shown that given the existence of asymmetric information and a misalignment of interests and strategic goals between venture capitalist and enterprises, venture capitalists may expropriate investee enterprises via the “financial tunnel effect” and “operational tunnel effect” in order to steal innovative ideas, which they can then apply to other start-up firms under their control. Such a phenomenon is particularly likely to occur in the early investment stage when VC is at relatively lower levels (Hsu, 2004; Ueda, 2004; Atanasov, 2006; Dushnitsky and Lenox, 2006).

According to the above arguments, there is a possibility that the relationship between venture capital and innovation could be non-linear. For instance, Bertoni et al. (2010) and Bottazzi and Da (2002) believe that serious asymmetric information usually exists among investors and entrepreneurs when venture capital effectively starts up enterprises' innovation. Similar viewpoints arise from Popov

* Corresponding author.

E-mail address: cpchang@g2.usc.edu.tw (C.-P. Chang).

¹ In accordance with the agency cost theory, VC managers provide close supervision (i.e. monitoring) of portfolio firms after the investment event, except for detecting potential problems in reducing agency costs, but also with the purpose to increase portfolio firm performance (Croce et al., 2013). Thus, VC offers value-adding services, including coaching, mentoring, and access to investment bankers.

and Roosenboom (2012) who mention that the effects of venture capital may have a greater impact on innovative activity when the VC investment level is relatively higher. Generally speaking, these studies show that higher levels of venture capital are much more influential than lower levels,² thus presenting potential asymmetric linkages between venture capital and innovative behavior (Aghion et al., 2015).³ This suggests that the non-linear relationship linkages between the variables should be easily revealed, as economists have lately witnessed an increased use of non-linear models that are able to capture asymmetry in macroeconomic time series.⁴

The major contributions of this paper are as follows. First, we investigate the non-linear relationship between venture capital (measured by the total amount of capital managed by the VC firm and the number of VC investment funds) and technology innovation (measured by the ratio of total provincial venture capital investments to GDP (PVCi, hereafter) and the ratio of total provincial venture capital investments to total investment (VCCF, hereafter)) for 28 provinces in China over the period 2001–2014, via the panel smooth transition regression (PSTR, hereafter) method.⁵ We prefer a smooth transition approach, because we believe that market participants in the VC industry are unlikely to take actions instantly and identically at the same time for the purposeful promotion of innovation, thus inducing the “heterogeneous beliefs” to move to a new regime (Hansen, 1999). In the PSTR model we consider that the impacts of VC on innovation performance change with region and time, and the model allows for a smooth and continuous switch between two regimes, which is different from most existing literature on VC-innovation models.

Second, the panel data approach gives more information, degrees of freedom, and efficiency, while at the same time controlling for individual heterogeneity. Therefore, focusing on a panel of provinces rather than on a single country permits us to learn about one individual performance by observing the behavior of others. Accordingly, based on PSTR specifications, we derive elasticities of VC that vary not only between provinces, but also with time. Hence, on the one hand, scholars believe that higher VC investment is usually linked with stronger innovative performance (see, for example, Kortum and Lerner, 2000; Aghion et al., 2015); on the other hand, bright innovation usually attracts more VC investors to invest in enterprises under the argument of the Grand Standing Hypothesis (Gompers, 1996; Faria and Barbosa, 2014). Thus, the problem of potential endogeneity exists in the innovation-VC nexus. To consider potential endogeneity, we utilize the Panel Smooth Transition Regression (PSTR) model with instrumental variables developed by González et al. (2005) and Fouquau (2008).

Third and finally, for a deeper investigation, given the significant regional variations and the disparity of venture capital investment across China, we divide our sample into eastern, central, and western groups as well as “higher-investment” and “lower-investment” provinces. We also separate the data of VC investment according to different “investment stage” and follow Hoenen et al. (2014) to categorize groups of “seed”, “initial”, “growth”, “transition”, and

² The proportion of shares held by VC investors usually correlates to the degree of industrial innovation. In other words, as they only hold a small amount of shares in investee enterprises in the early stage, they cannot exert any substantial influence on innovation (Aghion et al., 2015).

³ There is also existing asymmetric information between venture capital and the investee, when the scale of enterprises is small and there is a lack of venture capital. At this time, investors can easily expropriate innovative projects or ideas from the firms, because the investee cannot select a highly reputable investor (Hsu, 2004; Bachmann and Schindele, 2006; Arqué-Castells, 2012).

⁴ See, for example, Chang and Lee (2010), Chang and Lee (2013), and Chang and Lee (2015).

⁵ This is because panel data provide much more information than either cross-sectional data or time series data (Chang and Lee, 2010).

“reconstruction”. Hence, if non-linear relationships between VC and innovative performance can be supported, then pioneers in this field could examine more issues regarding VC and innovation. Using the estimated slope parameter and transition speed in PSTR, we offer clues for follow-up research and present other factors that actually give rise to a non-linear relationship.

We note that previous findings, unfortunately, usually omit the endogenous problem when investigating the linkages among variables. From the traditional perspective, most studies establish their theoretical framework using a patent production function and consider VC investment as an innovation input like R&D investment. This specification commonly a priori assumes that VC denotes an influential innovation, but not vice versa; in other words, researchers commonly suppose that there is only a unidirectional causality running from venture capital to innovation, with innovation does not adversely affect venture capital (Geronikolaou and Papachristou, 2012; Hirukawa and Ueda, 2011). Nevertheless, Hirukawa and Ueda (2011) believe that there still exists a backward causal relationship running from innovation to VC. For example, a very important innovation may motivate the emergence of a brand-new industry that is in desperate need of capital, management skills, technologies, and other complementary resources in the earlier life cycle, which subsequently brings forth venture capital input.^{6,7}

The advantages of a unitary country analysis are that it keeps track of national characteristics and leads to more accurate inferences. For example, Chang and Lee (2009) propose that time series studies of an individual economy offer important advantages over cross-country growth regressions. Arestis et al. (2001) also indicate that this method can provide useful insights into differences in such relationships across countries and may illuminate important details that are hidden in averaged-out results.

We believe that China is an interesting case study for several reasons. First, its economy has enjoyed a remarkable growth rate of approximately 10% per annum in the past few decades, and this rapid economic growth has created substantial changes in the structure of production in the nation’s industrial sectors. Second, a rapid increase in the opening up of its financial markets, strong marketization for innovation, and China’s economic growth following an industry-led strategy mean that more reliance should be placed upon capital investment. Third, according to the Chinese Innovation Ecosystem Report released in 2016, China has made significant and considerable progress in innovation, - China’s gross domestic expenditure on R&D has reached 1.422 trillion RMB or 2.1 percent of gross domestic product, making up approximately 20 percent of total global R&D expenditure, and such enormous investment in R&D activities and human resources has provided good resources for China’s innovation activities. The input in R&D activities of local Chinese enterprises has increased nearly 32-fold between 2005 and 2015 - namely, from US\$1.2 billion in 2005 to US\$39.4 billion in 2015. The massive improvement in the innovation input makes China an unavoidable sample country for relevant research on the topic of innovation.

Although the VC industry in China has emerged relatively late and has a shorter development duration, it is still important to

⁶ More details that describe the potential endogenous problem among VC and innovation are in Tang and Chyi (2008).

⁷ Concerning the empirical finding, Hirukawa and Ueda (2011) utilize a panel autoregressive distributed lag model and a Granger causality test to figure out that when using total factor productivity (TFP) to proxy for innovation, an increase in TFP significantly leads to an rise in VC investment during the early investment stage. Apart from evidence in the U.S., Geronikolaou and Papachristou (2012) test the interrelationship between innovation and VC using data from 15 European countries from 1995 to 2004. For the sample of countries, the authors figure out that innovation generates demand for venture capital instead of government subsidies.

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