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Spatial collocation and venture capital in the US biotechnology industry

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ABSTRACT

Biotechnology firms operate in a high-risk and high-reward environment and are in a constant race to secure venture capital (VC) funds. Previous contributions to the literature show that the VC firms tend to invest locally in order to monitor their investments and to provide operating assistance to their target firms. Further, biotechnology is a knowledge-based industry that tends to exhibit spatial clusters, and the firms in such industries may collocate to benefit from gaining access to local markets for specialized inputs (e.g., skilled researchers) and from local knowledge spillovers and network externalities. If such gains exist, we expect that the collocated firms should exhibit positively correlated performance, including in their ability to attract venture capital funds. The purpose of this paper is to empirically measure the strength and spatial extent of the relationships among the amount of funds raised by proximate biotechnology firms. We model these relationships with a spatial autoregression (SAR) model, and we control for characteristics of the biotechnology firms and the VC firms that provide their funds as well as site-specific factors. Based on our fitted SAR model, we find that the amount of venture capital raised by a particular biotechnology firm is significantly influenced by the number of VC firms and the VC funding levels raised by biotechnology firms located within a 10-mile radius, but these relationships are not statistically significant beyond this range.

1. Introduction

Biotechnology is a leading growth industry in the United States with high rates of new firm creation (Ernst and Young, 2009) and revenue growth (Datamonitor, 2009). The sustained development of the industry has been fueled by the country's leading position in global biotechnology innovation, top research and development (R&D) intensity and high quality of business climate (Scientific American, 2009).

Despite its impressive growth over the past 30 years, biotechnology remains a risky and capital intensive industry due to the high cost of developing new products, the lengthy product development process, and the uncertainties of achieving commercial success when the products are brought to market (Haussler and Zademach, 2007). For example, the average R&D cost for the development of a new drug product exceeds $802 million (DiMasi et al., 2003) due to the complex science and the strict regulatory environment. These industry characteristics are not conducive to successful debt financing arrangements (Carpenter and Petersen, 2002), but venture capital firms (VCFs) are attracted by the high-risk and high-reward nature of biotechnology investments (Amit et al., 1998; Gompers and Lerner, 2001; Lam, 1991; Timmons et al., 2003). The ample availability of venture capital has been a significant contributing factor to the growth of the US biotechnology industry (Audretsch, 2001; Champenois et al., 2006; Eliasson et al., 1997; Valentin et al., 2008; Waxell and Malmberg, 2007). Furthermore, VCFs do not contribute just financial capital but also valuable human capital and other forms of operating assistance to dedicated biotechnology firms (DBFs), especially through the early stages of their development (Carpenter and Petersen, 2002; Champenois et al., 2006; De Bettignies and Brander, 2007).

In general, VCFs and DBFs tend to locate in close proximity and alternative theories have been proposed to explain this collocation. First, VCFs tend to fund local target firms in order to reduce the impact of information asymmetries, principal-agent problems, and the costs of transit and other transaction costs (Sorenson and Stuart, 2001). Second, VCFs and DBFs tend to collocate in order to gain access to local markets for specialized inputs (e.g., skilled researchers) and to capture potential knowledge spillovers and network externalities (Sorenson and Stuart, 2001). The qualitative existence of such spatial relationships has been discussed

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and empirically demonstrated in earlier papers (e.g. Gupta and Sapienza, 1992; Sorenson and Stuart, 2001).

Given these considerations, we may expect DBFs to raise more VC funds as the number of neighboring VCFs and DBFs increases because the local supply of venture capital will tend to expand and because these DBFs may perform better by capitalizing on local labor markets, knowledge spillovers and network externalities. It may also be possible that their relative success in VC fund raising could spill over to other proximate DBFs. Since knowledge spillovers, network externalities and local supply of VC have geographic boundaries, any gains in the VC funding of DBFs from such spatial relationships should be expected to wane as the incidence of collocation diminishes. The purpose of this paper is to examine the potential presence, strength and spatial extent of such relationships among the VC funding levels attracted by proximate DBFs in the United States.

More specifically, we tackle three separate but related questions: First, do DBFs attract more VC funding as the number of VCFs located in close proximity increases? Second, do DBFs attract more VC funding as the number of DBFs located in close proximity increases? Third, is the level of VC funding achieved by individual DBFs influenced by the level of VC accumulation of their neighbors? In this last instance, we specifically want to know if the VC funding levels of proximate DBFs are positively correlated after controlling for the number of neighboring DBFs and VCFs. We are interested in these three questions because if such spatial relationships existed they could have significant reinforcing effects on firm collocation, industry clustering, local employment growth, and wealth creation.

Unlike most of the established empirical literature on this topic, we evaluate the potential presence and spatial extent of these relationships with an explicit model of the funding levels achieved by the individual DBFs. To address the three questions stated above in the presence of possible correlation among the firm-specific VC funding levels, we use an extended spatial autoregressive (SAR) model that allows the spatial correlation parameters to vary with distance. The fitted SAR model also controls for the local supply and demand for VC by including firm-specific variables to represent the characteristics of the funding VCFs and neighboring DBFs as well as site-specific factors.

The paper is organized as follows: in Section 2, we review the relevant literature and present our research hypotheses. In Section 3, we specify the spatial econometric model used to test our research hypotheses, and we describe our data sources in Section 4. We then discuss the estimation and test results in Section 5, and we offer concluding comments in Section 6.

2. Literature review and research hypotheses

We draw upon several distinct segments of the literature on venture capital funding to develop our testable hypotheses about the spatial relationships among VC funding levels for proximate DBFs. Based on our review of this literature, we find that such relationships maybe associated with: (1) the potential gains for VCFs and DBFs to collocate and (2) the potential gains for DBFs to locate in close proximity to other DBFs. In particular, the existing literature implies that we should expect the DBFs to be more successful and raise more VC funds as the number of neighboring DBFs and VCFs increases. Further, the relative success of a DBF (as measured by its VC funding level) is expected to spillover to proximate DBFs while holding the number of neighbors constant. In this section, we review the relevant literature and state our testable hypotheses. We also review the related research on other factors that may affect firm-specific VC funding levels, and we use this evidence to help select appropriate explanatory variables for our empirical model in order to control for these effects.

2.1. Collocation among biotechnology and venture capital firms

One segment of the relevant literature focuses on the critical role of VCFs in funding knowledge-based industries such as biotechnology, and there are several dimensions to the VCF–DBF relationship that may contribute to the collocation of these firms. For example, Sorenson and Stuart (2001) distinguish between the pre-investment and post-investment stages of the VCF decision process, and at each stage different factors may encourage collocation of the firms. In the pre-investment stage, VCFs may join localized social networks and develop local professional relationships in order to reduce the costs of generating investment leads and limit the asymmetry of information. The value of these networking relationships has also been recognized by other authors, including Owen-Smith and Powell (2004), Döring and Schnellenbach (2006), and Huggins and Johnston (2010). As such, VCFs tend to operate locally (Sahlman, 1990), have a strong industry-specific and geographic focus (Gupta and Sapienza, 1992), and often form local networks with other VCFs that can generate knowledge that is not publicly available (Shane and Cable, 2002).

During the post-investment stage, spatial proximity between the VCFs and their target firms may reduce the cost of monitoring the investment outcomes. As well, the VCFs tend to contribute considerable amounts of human capital in varying forms to the DBFs. These contributions may include filtering of information, screening of projects, and creation and dissemination of new knowledge (MacMillan et al., 1989) and can improve the potential success of the VCFs' investments. A number of studies have demonstrated that these VCF managerial contributions improve wealth creation (De Bettignies and Brander, 2007; Lam, 1991; Wijbenga et al., 2003) and innovation efficiency (Kortum and Lerner, 2000; Langeland, 2007; Muller et al., 2004; Wonglimpiyarat, 2006).[1] To this end, Haussler and Zademach (2007) conclude that regions with a balanced presence of VCFs and DBFs exhibit the best financial performance.[2]

The VCFs are therefore expected to locate close to other VCFs and to DBFs. In some cases, the VCFs may request that their target DBFs move to proximate locations in order to improve the chances of capturing these gains. With the potential gains from the collocation of VCFs and DBFs in mind, we form the following hypothesis:

H1. The level of VC funding for a DBF increases with the number of VCFs located in close proximity to the DBF.

2.2. Collocation among biotechnology firms

In the past several years, a large number of studies have suggested that positive agglomeration externalities emanate from the spatial collocation of similar firms (e.g. Amin and Wilkinson, 1999; Cooper and Folta, 2000; Rocha and Sternberg, 2005), particularly in knowledge-based industries which often rely on tacit knowledge. For instance, researchers have reported that collocation of similar firms (among them DBFs) and other industry participants can produce efficiencies in knowledge creation (Coenen et al., 2004; Gittelman, 2007; McKelvey et al., 2003; Moodysson and Jonsson, 2007) and firm growth (Beaudry, 2001; Henderson, 1997). The main argument in these studies is that geographic proximity assists the transmission of tacit knowledge (Adams and Jaffe, 1996; Aldrich and Wiedenmayer, 1993; Feldman, 1999; Fontes, 2005; Jaffe et al., 2005; Meyer and Rowan, 1977; Thornton, 1999;

[1] For studies analyzing the potentially negative effects of VC financing, see Wasserman (2003), Gompers (1996), Lee and Wahal (2004), Zacharakis and Meyer (1998), and Fischer and Pollock (2004).

[2] In contrast, Dahlander and McKelvey (2005) criticize claims of the potential importance of spatial effects among VCFs and DBFs.