



# Venture capital investments and the technological performance of portfolio firms



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## ABSTRACT

What is the relationship between venture capitalists' selection of investment targets and the effects of these investments on the patenting performance of portfolio companies? In this paper, we set out a modelling and estimation framework designed to discover whether venture capital (VC) increases the patenting performance of firms or whether this effect is a consequence of prior investment selection based on firms' patent output. We develop simultaneous models predicting the likelihood that firms attract VC financing, the likelihood that they patent, and the number of patents applied for and granted. Fully accounting for the endogeneity of investment, we find that the effect of VC on patenting is insignificant or negative, in contrast to the results generated by simpler models with independent equations. Our findings show that venture capitalists follow patent signals to invest in companies with commercially viable know-how and suggest that they are more likely to rationalise, rather than increase, the patenting output of portfolio firms.

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## 1. Introduction

New firms can rarely rely on internal cash flows in their pursuit of entrepreneurial opportunities. Among the sources of external finance available to entrepreneurs, venture capital (VC) can provide not only the financial resources they require, but also assistance to enhance the design, development, and performance of portfolio companies (Lerner, 1995; Bergemann and Hege, 1998; Gompers and Lerner, 2001; De Clercq et al., 2006; Schwienbacher, 2008; Cumming, 2010).

Among the different dimensions of entrepreneurial growth that the literature has noted, a strong association has been identified between VC investments and innovation, often measured by the firm's patenting output. A prominent thesis is that venture capitalists improve investee firms' innovative performance through their ability to 'coach' new businesses and to nurture them to produce greater technological output (Kortum and Lerner, 2000; Popov and Roosenboom, 2012). An alternative argument has received

relatively less attention as yet, although its validity may lead to a different conclusion: that venture capitalists are exceptionally good at identifying new firms with superior technological capabilities, which they see as the best investment opportunities. Seen from this angle, the most distinctive trait of VC, and therefore the most salient explanation for the stronger technological performance of VC-backed firms relative to other firms, would be the venture capitalists' superior selection capabilities (Baum and Silverman, 2004).

Venture capitalists face a resource allocation problem characterised by high risk and strong information asymmetries. In order to decrease these information asymmetries – given that potential investees have little or no track records of market performance – investors have to rely on other signals of firm quality. These include the *ex ante* patenting performance of potential investees (Häussler et al., 2012; Conti et al., 2013b; Hsu and Ziedonis, 2013), so patenting can be seen as an antecedent of VC investment decisions, as well as a likely consequence. Disentangling the relationship between VC investment and firms' technological performance involves a significant theoretical as well as empirical challenge because of endogeneity and reverse causation between the investment and innovation processes.

This is an important problem, not only from a scholarly perspective but also from a policy viewpoint. Even though the VC sector finances only a minority of new firms, it plays a very prominent

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role in policies designed to overcome finance gaps and to grow entrepreneurial, innovation-driven economies (OECD, 2014). This role has not gone unquestioned: critical issues have been raised about scale and skills in the demand and supply of venture finance (Nightingale et al., 2009), governance (Lerner, 2009), cyclicity and stage distribution of investments (Kaplan and Schoar, 2005; Cumming et al., 2005; Lahr and Mina, 2014), and the overall returns and long-term sustainability of the VC investment model (Mason, 2009; Lerner, 2011; Mulcahy et al., 2012). These make it even more important to gain a clear and accurate understanding of the VC-innovation nexus.

In this paper we model the relation between VC and patenting using simultaneous equations to consider both the determinants of VC investments, including patents as signals of firm quality, and the effect of VC on firms' post-investment patenting performance, controlling for their prior performance. We use data from an original survey of 3669 US and UK companies. We extract information on the 940 firms that sought finance between the years 2002 and 2004 and match these records with patent data extracted from the European Patent Office's Worldwide Patent Statistical Database (PatStat) for the periods concurrent to and following the survey years. Controlling for other firm characteristics (e.g. size, age, R&D expenditure, and market size), we estimate simultaneous models for (1) the likelihood that firms' patenting activities predict VC investments and (2) the likelihood that such investments lead to patenting in the following period. We employ a bivariate recursive probit model and develop a simultaneous zero-inflated Poisson model for count data, using both to control for the endogenous nature of the selection and coaching processes.

We demonstrate that, once we account for endogeneity, the effect of VC on the subsequent patenting output of portfolio companies is either negative or insignificant. These results indicate that, while venture capitalists positively react to patents as signals of companies with potentially valuable knowledge, confirming the 'selection' hypothesis, there is no evidence of a positive effect of VC investment on firms' subsequent patenting performance. It is plausible that VC will positively influence other aspects of new business growth (i.e. commercialisation, marketing, scaling up, etc.), but the contribution of VC does not seem to involve increasing investee firms' technological outputs. Importantly, the fact that the technological productivity of a firm may slow down after VC investment does not imply that the firm would be better off without VC: on the contrary, an insignificant or negative effect of VC on firm patenting suggests that venture capitalists rationalise technological searches and focus the firm's finite resources, including managerial attention, on the exploitation of existing intellectual property (IP) rather than further technological exploration.

This paper advances our understanding of the financing of innovative firms by modelling the determinants of investment choices by VC and the patenting output of their portfolio companies at the time of and after VC investment. In so doing, the paper also introduces an original methodology that can disentangle the endogenous relationship between VC and patenting efficiently, and has the potential for further uses in treating analogous theoretical structures.

## 2. VC investments and patenting: Theory and evidence

Investments in small and medium-sized businesses, and in particular new technology-based firms, pose specific challenges to capital markets because they involve high risks and strong information asymmetries (Lerner, 1995; Hall, 2002). From an investor's viewpoint, the economic potential of these firms is difficult to assess given their short history and the lack of external signals about their quality (e.g. audited financial statements, credit

ratings), or of market feedback about new products and services at the time of investment. Only few investors are able and willing to back these businesses. They do so with the expectation of satisfactory returns by applying a specific set of capabilities, and often sector-specific business knowledge, that enable them to make better choices relative to competing investors, handle technological and market uncertainty, and actively influence the outcome of their investments (Sahlman, 1990; Gompers, 1995; Hellmann, 1998; Gompers and Lerner, 1999, 2001; Kaplan and Strömberg, 2003, 2004).

In the extant studies that have addressed the links between VC and innovation, one stream has focused on the ability of venture capitalists to assist portfolio companies by giving them formal and informal advice, thus adding value in excess of their financial contributions (Gorman and Sahlman, 1989; Sapienza, 1992; Busenitz et al., 2004; Park and Steensma, 2012). A second and more recent stream has instead emphasised the ability of VCs to use patents as signals of firm quality and to make superior choices, relative to other investors, among the investment options that are available to them. If what matters for the subsequent performance of portfolio companies is the quality of the initial investment decision, the source of venture capitalists' competitive advantage rests on their selection capabilities, defined as their ability to identify the investee companies with the greatest growth potential (Dimov et al., 2007; Yang et al., 2009; Fitza et al., 2009; Park and Steensma, 2012). In the following two sections we review the arguments and evidence behind these two perspectives.

### 2.1. The effects of VC on patenting

The proposition that venture capitalists are able to increase firm value beyond the provision of financial resources has gained considerable support in the literature (Gorman and Sahlman, 1989; Sahlman, 1990; Bygrave and Timmons, 1992; Lerner, 1995; Keuschnigg and Nielsen, 2004; Croce et al., 2013), and is especially clear when they are compared, for example, to banks in the supply of external financing to small and medium-sized enterprises (Ueda, 2004). Venture capitalists can take active roles in many aspects of the strategic and operational conduct of their portfolio firms, including the recruitment of key personnel, business plan development, and networking with other firms, clients and investors, often on the basis of in-depth knowledge of the industry (Florida and Kenney, 1988; Hellmann and Puri, 2000, 2002; Hsu, 2004; Sørensen, 2007).

Several studies find links between VC investments and firms' patenting performance, and generally interpret a positive association between the two as a result of the 'value-adding' or 'coaching' effects of VC. One of the most prominent studies on this topic is Kortum and Lerner's (2000) paper, in which the authors model and estimate a patent production function in an investment framework. Aggregating patent numbers by industry, they find a positive and significant effect of VC financing on (log) patent grants<sup>1</sup>. Ueda and Hirukawa (2008) show that these findings become even more significant during the venture capital boom in the late 1990s. However, estimations of total factor productivity (TFP) growth reveal that this was not affected by VC investment, a result that contrasts with Chemmanur et al.'s (2011) study, which reveals a positive effect of VC on TFP. Popov and Roosenboom (2012) also find similar positive, although weaker, results for such effects in European countries

<sup>1</sup> Both patenting and venture funding could be related to unobserved technological opportunities, thereby causing an upward bias in the coefficient on venture capital, but regressions that use information about policy shifts in venture fund legislation to construct an instrumental variable also show positive impacts of VC investments on patenting (Kortum and Lerner, 2000).

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