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Does venture capital really foster innovation?

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HIGHLIGHTS

- We apply a dynamic panel data estimator to examine the impact of venture capital on innovation.
- We control for endogeneity.
- We employ additional exogenous instruments.
- We use data from 17 European countries.
- We find that venture capital has a positive impact on innovation mainly at a later stage.

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ABSTRACT

Using panel data of 17 European Union countries, we find robust empirical support for a positive impact of venture capital on innovation. After controlling for the potential endogenous relationship between venture capital and innovation, the results indicate that venture capital fosters innovation but mainly at a later stage.

1. Introduction

The role of venture capital (VC) in promoting innovation has received growing attention recently from both academics and policy makers. It has been argued that VC is particularly well suited to support the creation of innovative start-up firms. Frequently these new firms own innovative technologies but they lack financial resources as well as expertise in terms of market and entrepreneurial knowledge. For this reason governments of European countries have been concerned to foster VC as a means to achieve job creation, innovation and economic growth (Bottazzi and Da Rin, 2002).

However, the real effects of VC on innovation have been difficult to establish (Hall and Lerner, 2010; Dessí and Yin, 2012). This is largely due to the causality relationship between VC and innovation. On one hand, VC is aimed at supporting innovation. On the other hand, there could be more innovation not because VC caused it, but rather because venture capitalists reacted to the signalling of firms. In this case, the more innovative firms select venture capitalists for financing rather than VC causing firms to be more innovative. Hence in order to assess the true impact of VC on innovation this issue needs to be taken into account.

So far, few studies have dealt with the potential endogenous relationship (Popov and Roosenboom, 2012; Bertoni et al., 2011; Samila and Sorenson, 2011). However, most of these studies do not consider the dynamic nature of the data that typically characterizes innovation and, specifically, patent counts. Failing to do so will produce biased estimates. The studies by Bertoni et al. (2011) and Samila and Sorenson (2011) are the exception yet they do not investigate the impact of VC on innovation per se but rather on the number of firm start-ups or firm performance.

This paper fills this gap by estimating a dynamic panel data model for 17 European countries observed during 2000–2009 that allows us to control for the potential endogenous relationship between VC and innovation as well as to take into account the dynamic characteristic of our dependent variable. Our paper is close to the work of Geronikolaou and Papachristou (2012) and Popov

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Table 1
Empirical variables acronym, description, descriptive statistics and correlation matrix.

Variable	Description	Obs	Mean	Std. dev.	Min	Max
Panel A						
Patents	Ratio of patent applications at the EPO to GDP	170	0.010	0.015	0.000	0.062
VC	Ratio of total venture capital investments to total investment	186	0.006	0.005	0.000	0.036
VC_early stage	Ratio of early stage venture capital investments to total investment	186	0.002	0.002	0.000	0.013
VC_late stage	Ratio of late stage venture capital investments to total investment	186	0.004	0.004	0.000	0.023

	Patents	VC	VC_early stage	VC_late stage
Panel B				
Patents	1.000			
VC	0.188	1.000		
VC_early stage	0.131	0.819	1.000	
VC_late stage	0.192	0.971	0.658	1.000

Note: All variables are in log.

and Roosenboom (2012) in that we also use European country-level data.

2. Data and methodology

We use annual VC data obtained from the EUROSTAT statistics database. The observed countries are Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden and United Kingdom. Patent data refer to the European Patent Office (EPO) and were collected from the EUROSTAT database.

Following previous contributions (Hirukawa and Ueda, 2011; Geronikolaou and Papachristou, 2012) we choose patent applications rather than patent grants. The former are considered a good proxy for innovative ideas, whereas patent grants are a better proxy for innovative output (Hall and Lerner, 2010). In this sense, the signalling effect of a patent is more pronounced at the time of application rather than at the time of the patent grant, which seems more adequate to study the relationship between VC and innovation. Another reason justifying the use of patent applications is because there might be a significant time lag between filling an application and receiving a grant. From EUROSTAT we also obtained for each country data on business and government research and development (R&D) expenditures, the ratio of science and technology labour to total labour force, total aggregate investment and gross domestic product (GDP). From the Economic Freedom of the World (EFW) we collected an index of protection of intellectual property that ranges from 1 (low) to 10 (high) protection level.

Our main goal is to test for the impact of VC investments on innovation. Thus, country i's patent application function can be described as:

$$\text{Patents}_{it} = \beta_1 \text{Patents}_{it-1} + \beta_2 \text{VC}_{it} + \beta_3 X_{it} + \varepsilon_{it} \quad (1)$$

where Patents_{it} is country i's patent application ratio to country i's gross domestic product (GDP) in year t, Patents_{it-1} is its lagged value, VC_{it} is country i's investments in venture capital, measured by the ratio of total investments in venture capital to aggregate investment, X_{it} is a vector of control variables that are expected to influence country i's patent applications and not VC, and ε_{it} is an error term. The variables included in this vector are the ratio of R&D expenses to GDP, the ratio of science and technology labour to total labour force, and the index of protection of intellectual property.

The inclusion in all models of the lagged dependent variable as one of the covariates and the potential endogenous nature of the relationship between VC investments and patents require the use of appropriate estimation techniques. If causality between VC investments and patents runs in both directions then VC_{it} is endogenous in model (1) and correlated with the contemporaneous error term. An additional concern is the dynamic nature of (1), which gives rise to autocorrelation and Patents_{it-1} will be correlated with the country-specific unobserved individual effect.

To address these issues we follow the contributions by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) on dynamic panel-data models. The autocorrelation problem can be eliminated by taking first-differences of Eq. (1) to eliminate country-specific unobserved individual effects and use as instruments for $\Delta\text{Patents}_{it-1}$, lagged levels of the dependent variable from two or more periods before, which are not correlated with the residuals in differences, assuming no serial correlation in ε_{it}. The VC variable, being endogenous, can be instrumented in a similar way. The validity of the instruments used in the estimations can be checked using the Hansen-J test for overidentifying restrictions. The Hansen-J test is adequate in robust estimation and its null hypothesis is that the instruments are exogenous and, hence, valid. As additional exogenous instruments we include a measure of bank concentration, which is the ratio of total assets of the three largest commercial banks to total assets of all commercial banks and the corporate tax rate. These data were collected from the EUROBAROMETER. Descriptive statistics for the relevant variables are presented in Table 1.

3. Empirical results

Table 2 presents estimates for the patents applications function by the system generalized method of moments (GMM-SYS). For comparison purposes we also present estimates of Eq. (1) by pooled OLS. Although OLS estimates, column (1), produce biased estimates, they show a strong degree of persistence in patent applications as expected, and a non-significant coefficient on VC investments. For the GMM-SYS we use the one-step estimation with finite-sample correction for standard errors suggested by Windmeijer (2005). We instrument for the differenced equations, first-differences of the dependent variable using its levels lagged at least three periods, and its lagged first-differences as instruments for the level equations. VC investments are treated as endogenous and instrumented similarly to lagged patents. In order to limit the number of instruments we also apply a single moment condition for each period and regressor in columns (2) through (4).

Focusing on our key variable we can see from column (2) that VC investments are statistically significant. The tests for serial correlation in the error term reveal a significant AR1 and insignificant AR2. This result constitutes a first validation of the instruments used, which is then confirmed by the Hansen-J test of overidentifying restrictions. As expected the estimated coefficient of the lagged variable is smaller in GMM-SYS than in OLS. Columns (3) and (4) show the impact of early-stage VC and late-stage VC respectively. Interestingly, the estimates show that only late-stage VC has a significant impact on innovation. This result suggests that venture capitalists are more willing to support innovation only after the initial and more uncertain stage of technology development has been overcome.

Table 2
Estimates of the impact of venture capital on innovation.

Dependent variable: patents				
Estimator	OLS (1)	GMM-SYS (2)	GMM-SYS (3)	GMM-SYS (4)
$Patents_{it-1}$	0.926*** (0.033)	0.845*** (0.143)	0.814*** (0.168)	0.843*** (0.142)
VC_{it}	**0.019** (**0.013**)	**0.061*** (**0.032**)	–	–
VC_early stage$_{it}$	–	–	**−0.003** (**0.059**)	–
VC_later stage$_{it}$	–	–	–	**0.056**** (**0.026**)
Observations	135	132	126	132
Countries	17	17	17	17
R-squared	0.994	–	–	–
AR(1)	–	−1.83	−1.79	−1.81
(*p*-value)	–	(0.068)	(0.076)	(0.071)
AR(2)	–	1.54	1.33	1.46
(*p*-value)	–	(0.124)	(0.183)	(0.145)
Hansen test	–	12.25	10.85	12.28
(*p*-value)	–	(0.269)	(0.369)	(0.267)
DF		10	10	10

Notes: GMM stands for GMM system estimation; GMM estimates based on a reduced set of instruments with moment conditions in the interval $t-2$ to $t-5$ for equations in differences and equations in levels. All GMM estimates are based on the hypothesis of VC being endogenous and with finite sample correction proposed by Windmeijer (2005). Robust standard errors in parenthesis. All regressions include year dummies. AR(1) and AR(2) refer to first and second order autocorrelation tests. DF stands for degrees of freedom. OLS regressions with cluster robust standard errors. All regressions include control variables and additional instruments as described in Section 2.

* 10% significance level for which the null hypothesis is rejected.
** 5% significance level for which the null hypothesis is rejected.
*** 1% significance level for which the null hypothesis is rejected.

4. Conclusion

This research extends our understanding of the impact of VC investments on innovation at the country level. By explicitly addressing the potential endogenous relationship between VC and innovation and controlling for persistence in the patent series our results show that patent applications are in fact influenced by VC venturing. However, as one discriminates the effect of VC by its type or stage, results show that only the later-stage VC capital is promoting innovation. Hence, this result is consistent with the view that the VC role is more to help the commercialization of innovation rather than to foster its creation. These results provide policy makers with a clear picture of the true impact of VC on innovation and what and what not to expect from venture capitalists regarding their role in supporting innovation.

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