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Cities and Innovation

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ABSTRACT: This paper studies the relationship between venture capital (VC) and innovation using a self-collected dataset containing 119 innovative, VC-funded firms and 164,486 controls that operate in Spain. Probit model estimates indicate that firms that have applied for at least one patent are significantly more likely to obtain VC investments. However, when implementing a matching approach to correct for selectivity, no evidence is found of a significant impact of VC on firms' patenting activity. Rather, evidence is found of a positive effect of VC on the sales growth of funded firms. These results suggest that, rather than having an impact on innovation activities, venture capitalists (VCs) focus on the commercialization of existing products. A finer breakdown by ownership and investment stage also provides evidence that private VCs and early stage investments are notably more effective at stimulating sales than public VCs and late stage investments respectively.

JEL Codes: G24, O32

Keywords: Venture capital, innovation, patents, matching estimator.

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## 1. Introduction

It is well known that the traditional sources of financial intermediation are not well suited to support entrepreneurial innovation. Banks lend their money to low risk borrowers with collateral who can make timely payments of interest and principal. Most innovative firms, and particularly those that are newly created, do not meet these standards and are often denied credits and doomed to years of financial struggle.

Amid this gloom, venture capitalists (VCs) have been identified as the “free-market” answer to the financial problems of innovative start-ups. The main attribute of VCs is that they do not loan money in the style of traditional financial intermediaries: they do not ask for interest payments or collateral and yet they put money in the firm and bear the associated risks. If the firm grows to become profitable VCs get a share of the benefits, but if it fails VCs end up with nothing. In order to minimize this risk, VCs not only invest in the companies but they also take an active role in monitoring and helping them. In Botazzi and da Rin [1]’s words, “a non-financial “soft” side consisting of mentoring and monitoring complements the financial “hard” side of the capital contribution” (p. 235). All these particularities of VCs have led to the somewhat widespread belief that technology-oriented VCs are the ideal partners for financing corporate research and, in so doing, spurring entrepreneurial innovation.

Despite this conviction, the fact that VCs are of such benefit to innovation is not so clear-cut. A number of articles provide evidence that venture capital (VC) spurs innovation (Kortum and Lerner [2]; Mollica and Zingales [3]), while others contend that VCs convert science-oriented firms into business-oriented firms, thereby thwarting innovation (Engel and Keilbach [4]; Caselli, Gatti and Perrini [5]; Ueda and Hirukawa [6]). Correctly establishing the sequence in which VC investments and innovation take place is crucial to design effective policies for stimulating innovation. If innovation were to take place upon the entry of VC, policymakers could rely on VC as an innovation factor per se. However, if innovation took place before the entry of VC and VCs simply exploited those innovations, VC alone would not suffice to promote innovation and would need to be complemented with other sources of pre-innovation financing.

In this paper I seek to assert whether VCs simply focus on the commercialization of already existing innovations or also stimulate the innovativeness of their portfolio firms. The study is based on a dataset containing 119 VC-financed firms and 164,486 control firms which is the result of merging 1) self-collected data on roughly the entire population of Spanish high-tech firms that received VC investments between 2003 and 2007 with 2) patent data from the Spanish Patent and Trademark Office (OEPM), the European Patent Office (EPO) and the United States Patent and Trademark Patent Office (USPTO) and 3) financial data from the BvD's SABI database.

A common problem in this literature is the reverse causality in play between VC and innovation, which makes it difficult to establish whether VC funding causes innovation or innovation causes VC funding. This problem, however, is more acute in studies that use aggregated data (such as industry data) and I partly circumvent it by using firm-level data. Micro data, nevertheless, converts the reverse causality problem into a self-selection problem given that venture-funded firms are selected after intensive screening processes on the basis of superior performance. The failure to account for this phenomenon leads to inflated estimates of the contribution of VC to firm performance. My identification strategy will consist in matching venture-funded firms with non venture-funded firms that are equally likely to receive VC (conditional on their observable characteristics) prior to the VC investment. The matching partners will be used to build a counterfactual against which to compare the performance of venture-funded firms and so to estimate an average treatment effect. The implementation of matching estimators is plausible in the given context because venture-funded firms are observed before and after the entry of VC. Moreover, I observe a significant number of VC-funding determinants, which helps address the selection problem. In addition, the availability of a huge number of potential controls ensures the presence of suitable matches.

This paper contributes most directly to the empirical literature on VC and innovation (which I will discuss in detail in section 2), but also to the literature on VC and firm performance (see Hellman and Puri [7]; Engel [8]) and, more broadly, to the literature on the financing of innovation activities (see Hall [9] and Hall and Lerner [10] for two extensive surveys). One of the original contributions of this study is that, while existing articles consider the investments made by all types of VCs, I focus only on high-tech oriented VCs. This demarcation is important because VCs differ widely in their investment criteria and some are simply not interested in innovative activities. Such VCs are not expected to have a positive impact on firms' innovative performance and their inclusion might lead to underestimates of the role of truly innovation-oriented VCs. Another differential feature of this paper is that it not only reports estimates for the whole sample of VC-backed firms, but also for a finer breakdown by investment stage (early vs. late stage) and ownership of VCs (public vs. private). This focus on specific sub-samples allows me to assess the effectiveness of different types of VC investments, which is an interesting exercise with relevant policy implications. For instance, the existence of public support programs should be reconsidered if public VCs were found to be badly designed. On the other hand, early stage investments should be encouraged if they were found to achieve better results than late stage investments.

The rest of the article is organized as follows. Section 2 provides an overview of the literature. Section 3 presents the data. In section 4, I describe the estimation strategy. Section 5 verifies the accuracy of the matches. Section 6 presents the results. Section 7 concludes.

## 2. Literature review

The empirical literature on VC and innovation is divided into two groups. One provides evidence that VC spurs innovation; the other provides evidence that VC thwarts innovation. The former group is exclusively comprised of studies that use US industry data. The latter comprises papers that also draw on other sources including firm level data from European countries, qualitative evidence from specific case studies and personal opinions from entrepreneurs and VC professionals. In what follows I review all the empirical articles that shape the state of the art on VC and innovation. These articles are also schematically summarized in Table 1.

Zucker, Dardy and Brewer [11] study the determinants of the creation of biotech firms in the US. Although they do not explicitly analyze the relationship between VC and innovation, they are the first to provide a causal effect of VC on a variable considered as being highly linked to innovation. To avoid simultaneity problems, they use the number of venture capital firms active in 1981 (in each of the 183 US regions of their sample) to study the creation of biotech firms in 1990. They find that, controlling for the presence of intellectual capital, the size of the venture capital market negatively affected the creation of biotech firms. They interpret this negative effect, however, as evidence that VCs did play an active role in the formation of entrant firms which resulted in fewer albeit larger firms.

Kortum and Lerner [2] can genuinely be considered the first authors to explicitly study the relationship between VC and innovation. They propose a patent production function with two inputs, R&D and VC, to evaluate the patenting activity of twenty US manufacturing industries between 1965 and 1992. They use a 1979 change to the Employee Retirement Income Security Act that induced US pension funds to invest in VC as an instrument for VC investments and find VC to have a significant influence on patented inventions. Indeed their results suggest that a dollar of VC is three times more potent in stimulating innovation than a dollar of traditional corporate R&D. Similarly, Mollica and Zingales [3] also report evidence of a positive impact of VC on innovation using US industry data. They instrument the size of VC investments with the size of state pension fund’s assets and find VC investments to have a significant positive effect both on the production of patents and on the creation of new businesses.

Related articles in the literature, however, seem to contradict Kortum and Lerner [2] and Mollica and Zingales [3]. For instance, Engel and Keilbach [4] use a sample of German start-ups that received venture capital between 1995 and 1998 and find that while VC-funded firms have a higher number of patent applications than comparable firms before receiving VC; this difference vanishes after the investment is made. Growth rates of VC-funded firms, however, are still significantly larger than those of non-VC funded counterparts after the investment. This suggests that patents attract VC investments while VC does not improve firms’ patenting output. If anything VCs seem to focus on the commercialization of existing patents and on the growth of invested firms. Caselli, Gatti and Perrini [5] study a sample containing 37 venture-backed and 116 non venture-backed firms that went public between 1995 and 2004 and find the same results as Engel and Keilbach [4]. These results are largely in agreement with Stuck and Weingarten [12] who only find a tiny fraction of the 823 electronic high-tech initial offerings they track to be highly innovative. They claim that VCs thwart innovation and force their portfolio firms to become more business oriented for three main reasons. Firstly, VCs are not the risk takers they are often made out to be. Secondly, the short life cycle of VC funds does not allow for innovations to mature. And lastly, VCs general partners are more business oriented than science oriented.

Haeussler, Harhoff and Müller [13] back Engel and Keilbach [4]'s and Caselli, Gatti and Perrini [5]'s perception that patents attract VC. They analyze a representative sample of 190 German and British biotech firms (of which 87 received VC) that were founded after 1990 and find that having filed at least one patent substantially reduces (about 76%) the time to the first capital investment. Moreover, they also find that ventures with higher patent quality receive VC faster, which indicates that investors value quality and are able to screen it. Similarly, Hellman and Puri (2000) study a hand-collected database of 173 start-up companies located in Silicon Valley and find that innovators are more likely to be financed by VC firms than imitators. In addition, they also find that the presence of VC is associated with faster time to market.

Ueda and Hirukawa [6] explicitly study the reverse causality between VC and innovation using the industry data of nineteen US manufacturing sectors observed during the years 1968 to 2001. They ask whether it really is VC that causes innovation or the other way around. Using an AR regression, and working with the Granger causality concept, they find that lagged TFP growth explains present VC investments, but that the opposite does not occur. Indeed, they find lagged VC investments to be negatively correlated with present TFP growth. Induced by these findings, Ueda and Hirukawa [14] replicate Kortum and Lerner [2]'s paper using not only patents but also TFP growth as a measure of innovation. Like Kortum and Lerner [2], they find VC to have a significant influence on patented inventions. However, they cannot find VC to have any significant effect on TFP growth.

In addition to reviewing the scientific literature, it is also interesting to examine the interest of venture capitalists to finance R&D so as to get a better understanding of the relationship between VC and innovation. Sonnek [15], from SEB Venture Capital, explains that "venture capitalists dislike having to finance R&D. For us to be interested in financing a project, most of the R&D should be in place already". It is equally enlightening to listen to high-tech entrepreneurs who have received VC investments. According to Wadhwa [16] “we perfected our innovative technology long before we raised venture capital. (…) After receiving venture capital, our only focus was on sales and marketing”.

Table 1. Survey of the available evidence on VC and innovation

| Author | Data | Dependent variable | Independent variables | Methodology | Findings |
|---|---|---|---|---|---|
| **Evidence that VC spurs innovation** | | | | | |
| Kortum and Lerner [2] | Twenty U.S. manufacturing industries between 1965 and 1992 | U.S. patents issued to U.S. investors by industry and date of application on patent | Venture funding (collected by Venture Economics) and industrial R&D expenditures (collected by the U.S. National Science Foundation) | They propose a patent production function in which R&D and VC are the inputs. Reduced-form regressions are estimated both by OLS and IV. | 1) VC and R&D are highly substitutable; 2) VC has a significant influence on patented inventions: A dollar of VC is about three times more potent in stimulating innovation than a dollar of traditional corporate R&D |
| Mollica and Zingales [3] | Venture capital investments (at the industry level?) in the United States | Patents and new businesses | VC investment per capita | OLS and instrumental variables | 1) A one standard deviation increase in the VC investment per capita generates an increase in the number of patents between 4 and 15%; 2) An increase of 10% in the volume of VC investment increases the total number of new businesses by 2.5%. |
| **Evidence that innovations take place before VC investments and/or VC thwarts innovation** | | | | | |
| Ueda and Hirukawa [6] | U.S. manufacturing firms | Patent count, TFP growth and VC | Patent count (from the NBER), TFP growth (from the NBER productivity database and own calculation) and VC (VentureXpert) | They work with the concept of Granger causality: estimate whether lags of VC help predict TFP growth and innovation (and vice versa) | 1) Lagged TFP growth explains present VC investments, but the opposite does not occur; 2) Indeed, past VC investments are negatively correlated with present TFP growth. |
| Ueda and Hirukawa [14] | Nineteen U.S. manufacturing industries between 1968 and 2001 | U.S. patents issued to U.S. investors by industry and date of application on patent (from NBER) and TFP (from the NBER productivity database) | Venture funding (from VentureXpert) and industrial R&D expenditures (collected by the U.S. National Science Foundation) | Replicate Kortum and Lerner (2000) | 1) VC has a significant influence on patented inventions; 2) VC has no impact on TFP. |
| Engel and Keilbach [4] | Microdata on German firms. Covers all start-ups that received venture capital between 1995 and 1998: 142 treatments (or venture-funded) and 21,375 controls. | Firm growth (rate of average annual employment growth) and Innovative behavior (count data on patent applications at the German Patent Office). | A number of firm-specific variables such as number of employees, foundation date, sector, etc. | Non parametric matching procedures. | 1) Firms with higher innovative output have a larger probability of getting VC; 2) Venture-funded firms are not more innovative than their counterparts; 3) but display significantly higher growth rates. |
| Caselli, Gatti and Perrini [5] | A microlevel dataset of 37 venture-backed and 116 non venture-backed firms that went public between 1995 and 2004 | Patent count and sales growth | Not available | Non parametric matching procedures. | 1) Having patents seems a requirement to passing the VC's selection process; 2) entry of VC into the company does not promote continued innovation (indeed it seems to slow it down); 3) sales growth of VC funded firms is higher. |

Table 1. Survey of the available evidence on VC and innovation (continuation)

| Author | Data | Dependent variable | Independent variables | Methodology | Findings |
|---|---|---|---|---|---|
| **Evidence that innovations take place before VC investments and/or VC thwarts innovation** | | | | | |
| Haeussler, Harhoff and Müller [13] | Representative sample of active (in 2006) German and British biotechnology firms that were founded after 1990. 87 firms received VC and 103 did not | The time that the company receives the first VC financing | Dummy of patent application, patent application stock and average number of citations | Hazard rate analysis (Cox proportional hazard model) | 1) Having filed at least one application reduces the time to the first VC investment by 76%; 2) ventures with higher patent quality receive VC faster which indicates that investors value quality and that they are able to screen it |
| Hellman and Puri [7] | Hand-collected database of 173 start-up companies located in California's Silicon Valley. | Dummy indicating whether the firm receives VC financing, time to VC (time from the birth to the date of obtaining VC for the first time), time to market (time from the birth to the date of first product sale). | Dummy indicating whether the firm is innovator or imitator, dummy indicating whether the firm has received VC or not. | Probit for studying the determinants of VC financing, Cox estimations for studying time to VC and also for studying time to market. | 1) Innovator firms are more likely to be financed by VC than imitators; 2) Innovators obtain VC earlier in the life cycle than do imitators; 3) The presence of VC is associated with faster time to market. |
| Zucker, Darby and Brewer [11] | Panel for 14 years (1976-1989) and 183 US regions (functional economic areas). | Number of Biotech start-ups | Number of venture capital firms in a region legally eligible to finance start-ups in each year up to 1981. Fixing the number of firms at the levels of 1981 avoids simultaneity problems. | Poisson regressions on the sock of biotech firms. | 1) Controlling for the presence of intellectual capital, the size of the venture capital market negatively affected the creation of biotech firms. |
| Stuck and Weingarten [12]<br><br>Venture capitalists | 823 electronic high-tech initial public offerings for a 10-year period ending in 2002. | QUANTITATIVE FINDINGS: 1) Out of the total number of firms that received VC, only 20 (4.4%) and 5 firms (1.4%) were found to be highly innovative from 1993 to 1996 and 1997 to 2002 respectively.<br><br>QUALITATIVE EXPLANATIONS: 1) VCs are not the risk takers they are often made out to be; 2) The short life cycle for venture funds has dramatic consequences for innovation; 3) VCs general partners are more business oriented than science oriented. | | | |
| Sonnek [15]<br><br>Venture capitalist | Not available | "There are good reasons to work with venture-capital companies on corporate innovations –just so long as you don't expect them to pay for your R&D. (…) venture capitalists dislike having to finance R&D. For us to be interested in financing a project, most of the R&D should be in place already. If there is too much development left, it indicates there is still some technical risk, as well as making it difficult to estimate a commercial value. " | | | |
| Wadhwa [16]<br><br>High tech entrepreneur | Not available | "In both of our companies, we perfected our innovative technology long before we raised venture capital. And then we put significant effort into patenting part of our technology. Yes, we wanted to protect our assets, but this wasn't the key motivator –it was to make the company more attractive to venture capitalists, who we knew put a premium on patents. After receiving venture capital, our only focus was on sales and marketing. Technology development became a second priority." | | | |

Ueda and Hirukawa [17] argue that the apparently conflicting results of Kortum and Lerner [2] and Mollica and Zingales [3], on the one hand, and the remaining papers, on the other, are not necessarily incompatible. They point out that even if VCs only focused on the commercialization phase, they might still stimulate innovation by acting as an incentive: entrepreneurs could be more willing to innovate if they expected VC to help them in the commercialization stage. This conjecture goes beyond the scope of this paper but should be explored in future research.

My paper is most closely aligned with those of Engel and Keilbach [4] and Caselli, Gatti and Perrini [5] in the sense that I also use firm-level data and study the importance of 1) previous patent applications in attracting VC investments and 2) that of VC investments in spurring patenting activity and sales growth of financed firms. In contrast with these papers, however, I exclusively consider VCs that invest in innovative firms. Moreover, I provide results for different typologies of VC investments.

## 3. Data

This paper combines data from three different sources: 1) self-collected data on roughly the entire population of Spanish high-tech firms that received VC investments between 2003 and 2005, 2) patent data from the Spanish Patent and Trademark Office (OEPM), the European Patent Office (EPO) and the United States Patent and Trademark Patent Office (USPTO) and 3) financial data from the BvD's SABI database. In what follows, I describe the three datasets.

(1) Venture capital – The VC data has been obtained from several official sources, as well as from an exhaustive search across VCs websites and by phone calls to the VCs when relevant information was missing.

The main target was to obtain a sample as close as possible to the population of high-tech firms (or firms that conducted innovation activities) that received VC investments in Spain between the years 2003 and 2005 (both inclusive). In order to identify those firms, I began by creating a list of all VCs that operate in Spain (that is, both Spanish and foreign VCs that invest in Spain) and declare that they invest in high-tech and innovative firms. This was not a difficult task because VCs are very specific in their investment criteria and always state their orientation on their website. Besides this group of unambiguously high-tech oriented VCs, I also considered a group of generalist VCs who also seem to focus some of their interest on innovative firms.

With this list at hand, I began a search across several official sites that provide information on VC investments: BvD’s Zephir database, VentureXpert database and the Capital&Corporate yearbooks. Unfortunately, these three sources together do not provide a complete coverage of the whole population of high-tech VC investments. Hence, I complemented this first list with a search across the websites of all the VCs that operate in Spain. In some cases, however, it was impossible to infer the year when the investment was made or the nature of the investment (seed, start-up, development, MBO or MBI). These two sets of information are essential for the present study. The year of investment is necessary given that I want to match venture-funded firms with non-venture firms that have similar pre-investment characteristics. The type of investment is also important because I want to make sure that I only include VC investments (seed, start-up and development investments) while exclude private equity investments (MBOs and MBIs) that are not strictly speaking VC. Consequently, I initiated a round of phone calls to all the VCs for whom some information was missing (in practice, virtually the entire sample). This procedure proved very helpful because it not only yielded the missing information but also served to get valuable feedback from VCs about the quality of my data.

It can be appreciated in Table 2 that the number of high-tech venture-funded firms I have collected is consistent with the numbers reported by the European Venture Capital Association (EVCA). This indicates that my data contain almost the entire population of high-tech investments that took place during the years 2003 to 2005. Indeed, in most of the years I have more high-tech firms than those registered by the EVCA. This is not surprising given that I have been rather conservative in order to lower the risk of involuntarily excluding high-tech firms. Of all the investments I found, some were not properly speaking VC and I had to discard them. In some other cases, I either could not find the firms in the SABI database or they were in the SABI database but were lacking relevant information, which also led to their being excluded from the final econometric analysis. In the end, there are 119 firms that received (first round) VC investments during the years 2003 to 2005 for which all the necessary information is fully available. This roughly amounts to 30% of the population of VC investments that were made during these years according to the EVCA.

Table 2. Number of high-tech firms that received VC according to the EVCA and to my data

| | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|
| **EVCA data** | 110 | 122 | 172 | 404 |
| **My data** | | | | |
| All firms found | 171 | 141 | 193 | 505 |
| Proper VC investments [a] | 147 | 117 | 152 | 416 |
| Proper VC investments found in SABI | 110 | 75 | 79 | 264 |
| Included in the econometric analysis [b] | 43 | 36 | 40 | 119 |

Notes: [a] By proper investments I refer to those investments that can be deemed seed capital, start-up or expansion (and rule out all the other types of investments that are not VC). [b] I only include within the econometric analysis the firms found in the SABI for which I have no missing information.

(2) Patents – Firms' innovative behaviour is measured using patent applications made to the OEMP, the EPO and the USPTO to proxy the number of innovations produced by each firm. As is common, I use patent applications instead of granted patents because several years may elapse between the submission of an application and the granting of the patent. In consequence, patent applications are a better proxy for the ideas invented at a certain point in time. In the remaining of the article it should be borne in mind that whenever I refer to patenting I always refer to patent applications. While it is well known that patents are an imperfect measure of innovation (given that not all innovations are patented), it is the best measure to which I have access. Besides, they have been shown to be a better measure of research productivity than R&D (Griliches [18]). I have information of all the granted patent applications that were filed during the years 2000 to 2008, which consists of a total of 40,378 OEPM patents, 13,415 EPO patents and 1,469 USPTO patents.

(3) Financial information – The accounting information has been obtained from SABI. The main advantage of the SABI database is that it has a large coverage and contains, among the more than million firms that configure the whole database, most of the VC-funded firms in my sample. In addition, it includes many firms that are likely to be good controls for the VC-funded firms. As potential controls I take all the 180,000 firms that

show up in the SABI for more than 5 years, are available for the years 2003 to 2008, belong to industries with at least one venture-funded firm and were founded after 1994. Moreover, I also take a random sample of 40,000 firms that were founded prior to 1994. The characteristics taken from the SABI are firms' name, province, industry, age, number of employees, sales, operating profits and export status.

These three sets of information are merged using Stata's Reclink routine. The string used to carry out the matching is firms' name. I also experimented using a multiple criteria based not only on firms' name, but also on their address and zip code. However, it performed notably worse.

*3.1. A first look at the data*

The match resulted in a dataset containing 120,000 firms observed over several years, making a total of 961,784 firm-year observations. In order to construct some of the endogenous and explanatory variables, I need to observe each firm for at least four years: two years after the VC investment (to measure the sales growth rate in the two years following funding) and two years before the VC investment (to know the sales growth rate in the two years preceding funding). After deleting the observations that were observed for less than four years or for which information was missing, I ended up with 119 VC-funded firms and 164,486 non VC-funded observations.

Table 3 reports the descriptive statistics for the various subgroups. It is reassuring to see that the 119 VC-funded firms included in the analysis (shown in column 2) do not differ much from the 264 VC-funded firms found in the SABI database (shown in column 1). It seems that the firms considered in the analysis are slightly more innovative, older and larger and export more. By contrast, they present lower sales and profit growth rates. These differences, however, are not severe and it is possible to conclude that the sample used in the analysis is strongly representative of the larger sample of firms found in the SABI.

The differences between the VC-funded firms included in the analysis and the non VC-funded firms (column 7) are remarkable. VC-funded firms patent more (12% of VC-funded firms patent while only 1% of non VC-funded firms do so), more intensively (0.227 patents per firm against 0.016) and are more likely to export (38.7% of VC-funded firms export while only 8.2% of non VC-funded firms do so). Their sales are more than four times as large as those of non VC-funded firms, as are their sales' growth rates. Profit growth rates, however, do not differ. There are no substantial differences in age either. VC-funded firms, though, are considerably larger both in terms of number of workers and in total assets. Finally, VC firms are more likely to be private limited companies as opposed to limited liability corporations and have notably larger cash flows.

Table 3. Descriptive statistics

| | | VC firms included in the econometric analysis | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) All VC firms | (2) All | (3) Public | (4) Private | (5) Early stage | (6) Late stage | (7) No VC firms |
| Patent application | 0.103 | 0.118 | 0.061 | 0.209 | 0.118 | 0.113 | 0.010 |
| No. of Patents | 0.164 | 0.227 | 0.076 | 0.488 | 0.118 | 0.296 | 0.016 |
| Exporter dummy | 0.272 | 0.387 | 0.409 | 0.372 | 0.294 | 0.479 | 0.082 |
| Sales | 11,041 | 10,285 | 11,066 | 9,827 | 4,325 | 14,673 | 2,511 |
| Sales growth rate | 38 | 4 | 5 | 2 | 10 | 1 | 1 |
| Profits growth rate | 9 | 0 | -2 | 3 | -2 | -1 | 0 |
| Age | 9 | 13 | 13 | 12 | 9 | 16 | 9 |
| Workers | 69 | 71 | 63 | 74 | 33 | 93 | 19 |
| Total assets | 14,750 | 11,424 | 11,686 | 9,885 | 6,947 | 14,462 | 1,773 |
| Private limited | 0.624 | 0.521 | 0.515 | 0.558 | 0.529 | 0.465 | 0.868 |
| Cash flow | 613 | 565 | 589 | 658 | 102 | 849 | 127 |
| Number of observations [a] | 133/213 | 119 | 66 | 43 | 34 | 71 | 164,486 |

Notes: sample means are reported for each variable. More detailed descriptive statistics for each subgroup (with the standard errors, the minimum and the maximum values) are reported in the appendix. The means are calculated over firms' pre-VC characteristics. [a] Obviously, not all the information is available for the 264 VC-funded firms found in the SABI database. This is the reason why some have been excluded from the final analysis. Consequently, the means in column (1) have been calculated over the number of firms for which the corresponding variable is available (which ranges from 133 to 213 depending on the variable).

As regards the ownership of the VCs, Brander, Egar and Hellman [19] point out that a good public support program should be characterised by a considerable selection effect and a reduced treatment effect. The selection effect refers to the fact that public VCs should increase the equilibrium quantity of VC to the socially efficient level by investing in firms that are not profitable to private investors. We should, hence, observe public VCs investing in "inferior" firms rather than competing for projects that are attractive to private investors. Similarly, we should also expect public VCs to invest in more innovative firms in order to promote the creation of spillovers. This, however, does not seem to be the case. On the one hand public VCs invest less in innovative firms than do private VCs. On the other hand, public VCs invest more heavily in exporting companies and in firms with both larger sales and sales growth rates (although lower profits growth rates). In the case of the remaining characteristics (age, size, and cash flows), there seem to be no important differences. Therefore, public VCs apparently compete with private VCs for similar quality firms instead of favouring either more innovative or more handicapped firms. This evidence suggests that the "selection effect" requirement is not met. In the results section (section 6) I will discuss whether the second desirable feature of a well-designed public VC policy, namely the "no treatment effect", is met. The "no treatment effect" requirement implies that once we control for selection, public VCs should be equally effective as private VCs at stimulating both firms' innovation and sales growth rates. Therefore, it is necessary to carry out a proper econometric analysis to verify its validity.

Finally, the breakdown by investment stage provides very intuitive numbers: early stage investments are directed at younger and smaller firms which patent less, export less and have lower sales but which report much larger sales growth rates.

Besides looking at the descriptive statistics, it is also interesting to examine the evolution in firms' performance before and after VC entry. Figure 1 plots the evolution of sales, the share of patenting firms and the number of patent applications both for the firms that receive VC and for some suitable controls that are equally likely to receive VC[1]. It can be appreciated that the sales of VC-funded firms unambiguously grow more than those of the controls after VC entry. Nevertheless, the impact on patent applications is less clear. There is a sudden rise both in the number of firms that apply for at least one patent and in the number of patent applications in the precise year of VC entry. This boom lasts for one year and then it dissipates with patenting activity returning to pre-VC levels. This temporary increase seems to be the cause of VC entry rather than a consequence of it. Patentable innovations are generally the result of sustained research efforts that tend to last for more than one year and, in this sense, it

[1] The method used to select controls is carefully detailed in the econometric section (section 4).

seems unlikely that VCs have the ability to immediately boost firms' patenting activity. A more realistic explanation is that, during the screening phase, VCs are possibly able to detect firms with advanced research projects that are about to crystallise into patentable innovations. However, to evaluate the impact of VC on firms' performance more precisely, it is necessary to implement appropriate evaluation techniques that properly correct for such selection. The technique implemented in this paper is explained in the next section.

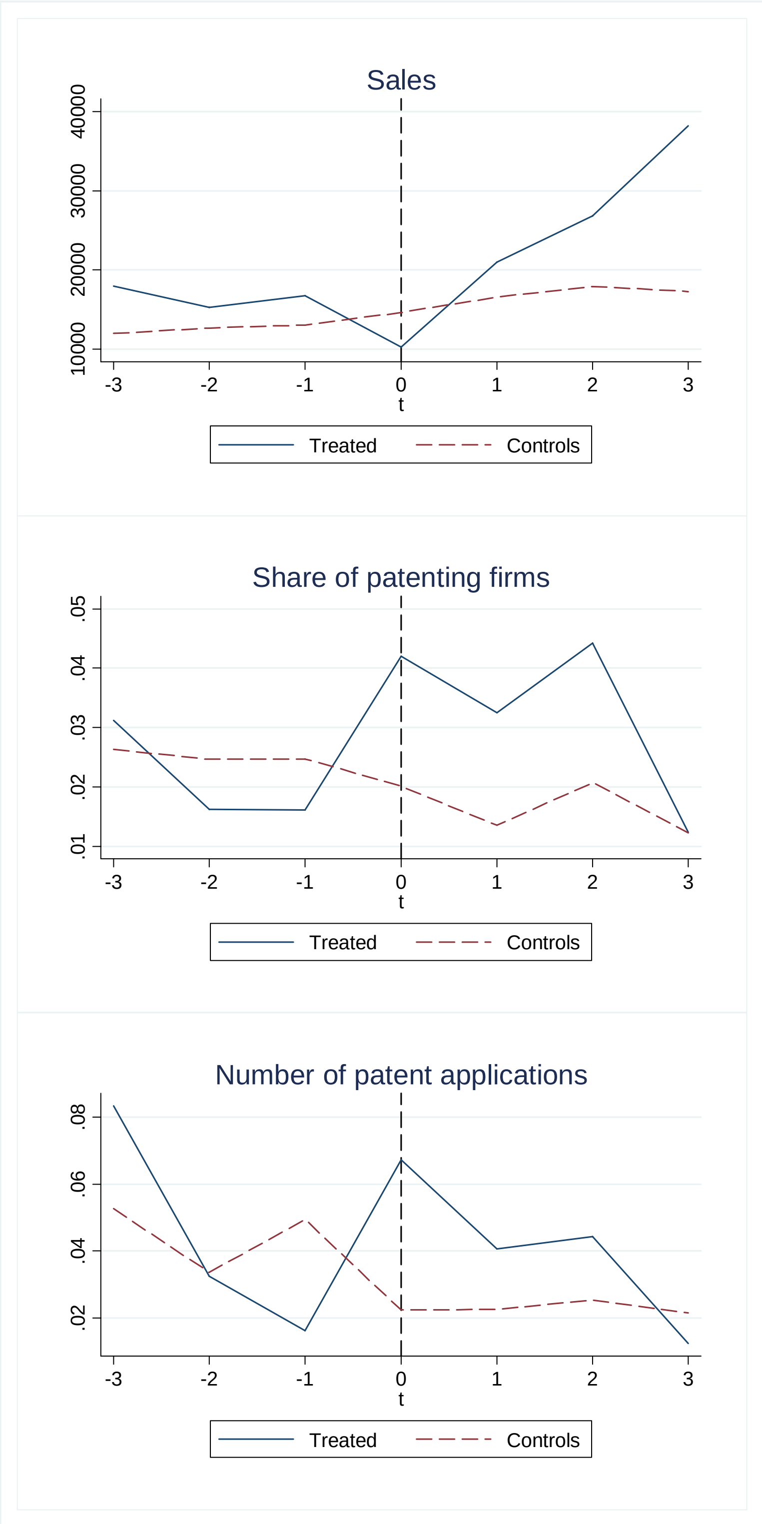


Figure 1. Evolution of firms' performance before and after VC entry

## 4. Estimation method

If we let $Y_{1i}$ and $Y_{0i}$ denote the potential outcome of firm $i$ in the presence and absence of VC respectively, the causal effect of VC on the performance of firm $i$ is given by $Y_{1i} - Y_{0i}$. Hence, to measure the effect of VC on patent applications and sales growth rates we would ideally wish to observe the difference between the firms' outcome after VC funding and the hypothetical outcome without funding. The main problem of causal inference, however, is that $Y_{1i}$ and $Y_{0i}$ are not simultaneously observable. Matching estimators, nevertheless, allows us to build the missing counterfactual provided that two identification conditions are satisfied. These conditions are:

1. $(Y_1, Y_0) \perp D \mid X$ (selection on observables)
2. $c < \Pr(D = 1 \mid X = x) < 1 - c \; with \; c > 0$ (common support)

Where $D$ is the indicator of treatment intake which takes the value one if the firm is VC-funded and zero otherwise and $X$ is a matrix of firm covariates.

The first identification condition states that, conditional on certain observable characteristics, the treatment is independent of the outcomes. In consequence, if the treatment is "random" for firms with similar pre-treatment characteristics, it is possible to use the average outcome of similar firms that are not treated to estimate the untreated outcome. Put formally, the selection-on-observables assumption implies that $E[Y_0 \mid D = 1, X = x] = E[Y_0 \mid D = 0, X = x]$. This allows us to estimate the average treatment effect of VC on firms' output as

$$\begin{aligned} \alpha_{ATE} &= E[Y_1 \mid D = 1, X = x] - E[Y_0 \mid D = 1, X = x] \\ &= E[Y_1 \mid D = 1, X = x] - E[Y_0 \mid D = 0, X = x] \end{aligned}$$

For the selection-on-observables assumption to hold, the set of characteristics included in $X$ should account for all the determinants of VC funding. Although there is no formal method to test the validity of the selection-on-observables assumption I seek to argue in the next section that the covariates used are sufficient.

The second assumption guarantees that for any VC-funded firm with a given covariate pattern it is possible to find non VC-funded firms with similar characteristics against which to compare them.

If these two conditions are satisfied it is possible to estimate the non-observed outcome of any firm using the outcomes of similar firms with the opposite treatment. The question, then, becomes how to identify "similar" firms. When $X$ is multidimensional or continuous, as is the case in this paper, it is impossible to find twin treated and control firms with exactly the same characteristics. In such cases, "closeness" is defined by a distance metric between the multivariate covariate vectors of the treated and the controls. A commonly used distance is the Mahalanobis distance: $D(X_i, X_j) = \sqrt{(X_i - X_j)' S^{-1} (X_i - X_j)}$, where $X_i$ is the covariate vector of the treated observation $i$, $X_j$ is the covariate vector of the control $j$ and $S$ is the variance-covariance matrix. In this paper, I will use the bias-corrected nearest-neighbour matching estimator proposed by Abadie and Imbens [20], which precisely implements the distance measure above defined to match treated and control observations. Abadie and Imbens [20] show that the simple matching estimator leads to a non-negligible bias if $X$ contains multiple continuous variables. They propose a bias correction that consists in adjusting the estimated counterfactual of $i$ for the difference between the covariates for unit $i$ and its match.

Matching estimators allow us to calculate the average treatment effect (ATE), the average treatment effect on the treated (ATET) and the average treatment effect on the controls (ATEC). Here, I am only interested in calculating the ATET given that I wish to evaluate whether firms that receive VC do better than they would have done without VC. The ATET is calculated as[2]:

$$ATET = \frac{1}{N_1} \sum_{i}^{N_1} \left[ Y_{1i} - \hat{Y}_{0i} \right]$$

[2] To match the treated firms with the controls and estimate the ATET I use the STATA's nnmatch routine described in Abadie et al. [21].

where $N_1$ is the number of VC-funded firms and $\hat{Y}_{0i}$ is the bias-adjusted, estimated counterfactual of firm $i$. Following Abadie et al. [21], I will match each treated firm with four controls because it offers the benefit of not relying on too little information. Thus, the unobserved outcome of firm $i$ will be estimated by averaging the observed outcomes for the four controls that will be chosen as matches for $i$.

## 5. Implementation of the matching procedure

The vector of covariates $X$ used in the matching procedure simply includes the propensity score (the estimated probability of being VC-funded), which is the most widely used variable in the matching literature. I also tried to choose the matches applying alternative criteria. For instance, I also added patent and export dummies to the $X$ vector. In addition, I also forced the matched partners to belong to the same industry, size stratum and year. None of these efforts, however, produced more accurate matches than those obtained with the propensity score alone. In any case, the results obtained with this alternative criteria were qualitatively the same and quantitatively very similar.

### *5.1. Probability of VC funding and validity of the selection-on-observables assumption*

To obtain the propensity score I estimate a probit model in which the dependent variable is a dummy with value one if the firm receives VC and zero otherwise. The explanatory variables used in the regression are a series of pre-treatment firm characteristics that can be considered relevant determinants of VC-funding. Firstly, I include a dummy variable with value one if the firm has applied for at least one patent up to the present time. This variable aims to approximate the innovative behaviour of the firm. It also serves to indicate whether firms have any new product or technology that VCs might be interested in. Secondly, I include a dummy that takes the value one if the firm exports and zero otherwise. It is well known that exporters have access to larger markets and as such enjoy better growth prospects, a fact that attracts VCs. Thirdly, I consider sales and profitability growth during the two years preceding VC entry to proxy firms' present and future potential performance. It should be acknowledged that I lack information on firms' managerial ability, which is likely to be an important determinant of VC entry. This information is commonly missing, unless surveys with specific questions on the topic are available. In the absence of reliable information on this dimension, both sales and profits growth rate will partly capture managerial ability.

Fourthly, VCs tend to follow specific investment criteria. Some focus on young small firms while others concentrate on mature large firms undergoing expansion. To capture these preferences I include firms' age and number of workers. To further control for size I also introduce firms' total assets. Fifthly, I include a dummy with value one if the firm is a private limited company and zero if it is a limited liability corporation. The reason why I consider this variable is that firms that adopt certain legal entities are less accessible owing to their reluctance to relinquish control to external shareholders. Induced by a similar rationale, I also introduce firms' cash flow as an indicator of firms' financial autonomy, given that financially able firms might be less attracted to VC. Finally, I include a full set of industry, region (at the province level) and year dummies to account for systematic differences in the VC activity across industries and regions, and to control for the business cycle.

Table 4. Probit estimate of the propensity score

| Dependent variable: VC dummy | | |
|---|---|---|
| Patent dummy | 0.256 | (0.081)*** |
| Exporter dummy | 0.450 | (0.078)*** |
| Sales growth rates | 0.000 | (0.000)** |
| Profit growth rates | 0.000 | (0.001) |
| Age | 0.001 | (0.004) |
| Workers | 0.000 | (0.000) |
| Total assets | 0.000 | (0.000)*** |
| Private limited company | -0.305 | (0.074)*** |
| Cash flow | 0.000 | (0.000) |
| Constant | -6.431 | (0.541)*** |
| Industry dummies | yes | |
| Region dummies | yes | |
| Time dummies | yes | |
| | | |
| Observations | 176,075 | |
| Adj. R-squared | 0.19 | |
| Correctly predicted observations | | |
| Zeroes | 0.61 | |
| Ones | 0.89 | |

Notes: Robust standard errors in parentheses. ***, ** and * indicate significance on a 1%, 5% and 10% level respectively. The t-ratios are shown in parentheses. The critical value used to classify the predictions is 0.024.

The coefficients of the probit estimation are displayed in Table 4. The results suggest that previous patent applications are a significant determinant of VC-funding. This result is consistent with studies elsewhere that support the "innovation-first" hypothesis. Similarly, firms that export and which have high growth rates are more likely to receive VC. As opposed to sales growth rate, however, profits growth rate does not seem to have any effect on VC participation. Firms' age and size do not play a major role at explaining VC investments, although total assets (another size proxy) do have a positive and significant coefficient. Private limited companies show a significantly lower probability of receiving VC than limited liability corporations, suggesting that certain organizational structures are more open to external partners. Cash flows have an insignificant effect on the likelihood of VC participation. As to the industry and region dummies, they reveal a great degree of heterogeneity across industries and regions. Lastly, it is worth noting that the fit of the model is good as implied by the large number of correctly predicted zeroes and ones and the acceptable value of the adjusted R-squared.

### *5.2. Comparison of treated and control firms and validity of the common support assumption*

To evaluate the quality of the matches, Table 5 compares the mean values of the propensity score and the variables included in the probit model for the treated and the selected controls. As an additional check of the accuracy of the matches, I also report the kernel densities of the propensity score for the treated firms and the selected controls.

In Table 3 I showed that the characteristics of VC-funded firms significantly differ from those of all the potential controls. Table 5 proves that these discrepancies almost disappear when we compare the treated firms with the selected control firms. There is a group of variables whose mean is virtually the same for the two subgroups. These variables are the propensity score, the exporter dummy, age, size and the private limited company dummy. Besides these variables, there is also a group of covariates whose mean differs substantially across the two groups. This is the case of the sales growth ratio and, to a lesser extent, of the patent dummy (the profit growth rates also differ, but since this variable is not significant in the probit estimate this discrepancy is less of a concern). These two discrepancies, however, work in a direction that should not cast any doubt on the results. For instance, and advancing some of the results that I will present in section 6, regarding the pre-treatment sales growth rate, the mean for the non-VC funded firms is much larger than the mean for the VC-funded firms and yet I find VC to spur sales growth rate. Conversely, while the pre-treatment share of firms that apply for at least one patent is larger for VC-funded firms, I cannot find compelling evidence that VC spurs patent applications.

Figure 2 plots the kernel densities of the propensity score of the treated and the potential controls. The two kernel densities perfectly overlap indicating that the common support assumption holds and that the propensity scores of the treated and the selected controls are not only identical in their means but also over the whole distribution.

Table 5. Mean comparison of VC-funded firms and selected controls

| | VC firms | Selected controls |
|---|---|---|
| Propensity score | 0.010 | 0.010 |
| Patent application dummy | 0.118 | 0.086 |
| Sales growth rates | 3.699 | 21.441 |
| Profits growth rates | -0.310 | -3.537 |
| Age | 12.588 | 12.832 |
| Workers | 71.202 | 82.393 |
| Exporter dummy | 0.387 | 0.382 |
| Private limited company | 0.521 | 0.577 |
| Total assets | 11424 | 12343 |
| Cash flow | 564 | 887 |
| Number of observations | 119 | 463 |

Notes: four matches are used to estimate the unobserved outcome of each VC-funded firm. I have selected the matches with replacement (each control can be chosen more than once) and this is the reason why there are 463 controls instead of 476 (4 times 119).

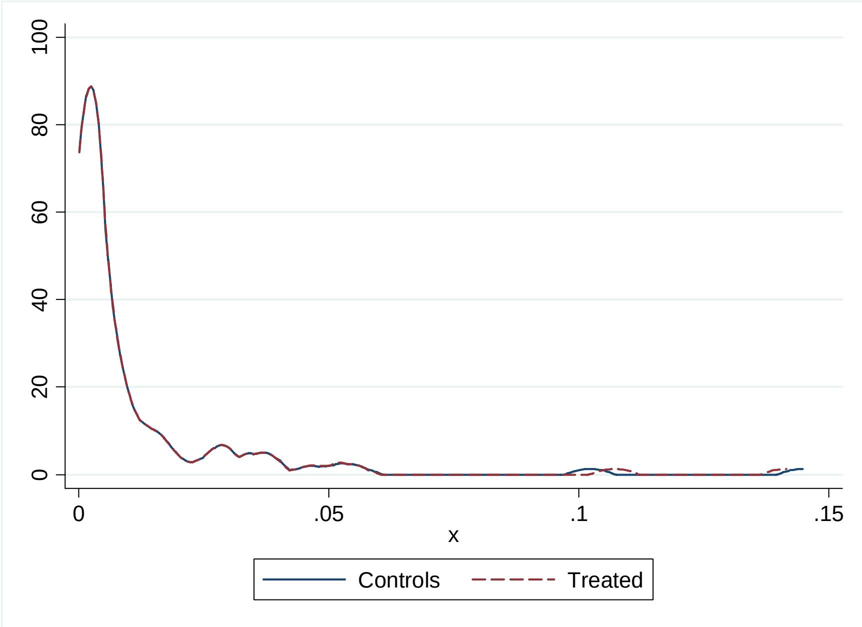


Figure 2. Kernel densities of VC firms and selected controls

## 6. Results and discussion

Table 6 presents the ATET of VC funding on the share of patenting firms, the number of patent applications and the sales growth rate of VC-funded firms. Besides reporting estimates for the whole sample of VC-funded firms, Table 6 also provides estimates of the ATET for different subsamples to see whether the effectiveness of VCs differs across ownership status (public vs. private) and investment stage (early stage vs. expansion). In the data section I reported descriptive evidence of the great boost in patenting activity that takes place at the precise moment of VC entry. I argued that this boost is unlikely to be the consequence of VC entry given that patentable innovations often involve projects that take more than one year. In order not to attribute to VC a positive effect on firms' patenting activity that is indeed due to firms' pre-VC efforts, I consider two definitions of the innovation-related variables (patent application dummy and the number of patent applications). In the first of these, I take into account the number of firms that applied for at least one patent and the number of patent applications observed from the exact moment of VC entry (t) onwards. The variables so defined are likely to suffer from an upward bias. In the second definition, I leave a prudential one-year gap and only consider the number of firms that applied for at least one patent and the number of patent applications observed after the first year (t+1) following VC entry. If VC really has an effect on firms' patenting activity, this effect should manifest itself using this definition too and not only when using the previous one.

Column (1) considers all VC-funded firms. The estimates indicate that VC does not stimulate the patenting behaviour of the invested firms but that it has a positive and sizeable effect on the sales growth rate in the two years following the investment. In particular, VC-funded firms exhibit a sales growth rate that is almost 20 percentage points higher than that of similar non VC-funded firms.

Columns (2) and (3) compare the performance of public and private VCs. Neither of them seems to have any impact on firms' patenting activity. In the case of private VCs, it is only possible to find a positive and significant effect when the first and more questionable definition of the patenting variables is used. This effect, however, is weak and vanishes when the more demanding definition is considered. As for the sales growth rate, both public and private VCs have a positive and significant effect on it. This effect, however, is notably larger for private VCs. In the data section I showed that public VCs did not meet the first desirable feature of a public support program, namely the "selection effect" requirement. At this stage, it is possible to state that they do not meet the "no treatment effect" requirement either. Recall that the "no selection effect" implies that, after controlling for selection, public and private VCs are equally effective. The estimates make evident that VCs are clearly superior at stimulating, if not innovation, at least the sales growth rate.

Table 6. Effect of Venture Capital on the share of patenting firms, on the number of patent applications and on sales growth rate

| | All (1) | Public VC (2) | Private VC (3) | Early stage (4) | Late stage (5) |
|---|---|---|---|---|---|
| Patent application dummy from t onwards | 0.029 | 0.008 | 0.081 | 0.007 | 0.028 |
| | (0.022) | (0.023) | (0.042)* | (0.031) | (0.030) |
| Patent application dummy from t+1 onwards | 0.019 | 0.008 | 0.041 | -0.015 | 0.018 |
| | (0.019) | (0.023) | (0.033) | (0.016) | (0.027) |
| Number of patent applications from t onwards | 0.040 | -0.011 | 0.174 | -0.007 | 0.067 |
| | (0.045) | (0.034) | (0.099)* | (0.042) | (0.066) |
| Number of patent applications from t+1 onwards | 0.027 | -0.008 | 0.105 | -0.022 | 0.042 |
| | (0.032) | (0.031) | (0.064) | (0.026) | (0.048) |
| Sales growth rate | 0.194 | 0.095 | 0.373 | 0.436 | 0.071 |
| | (0.070)*** | (0.058)* | (0.166)** | (0.193)** | (0.061) |
| Potential control group | 164,486 | 164,486 | 164,486 | 164,486 | 164,486 |
| Treated group | 119 | 66 | 43 | 34 | 71 |

Notes: The estimates reported are the ATET of VC entry on the share of patenting firms, the number of patent applications and sales growth rate. Bias adjusted standard errors are shown in parentheses. ***, ** and * indicate significance on a 1%, 5% and 10% level respectively. The ATET of VC on the share of patenting firms and the number of patent applications has been calculated twice. In the first case I considered the effect of VC from the precise moment of entry (t) onwards. In the second case I left a prudential one-year gap and only considered the impact of VC on the variables of interest from one year after the entry (t+1) onwards.

Finally, columns (4) and (5) report the estimates of early and late stage investments. Not surprisingly, neither of the investment stages is effective at promoting innovation. Strikingly, however, early stage investments are much more powerful at spurring sales growth rates than late stage investments which have no impact at all. Probably, VC makes more of a difference in young, small start-ups that lack the resources to expand on their own than it does in mature firms that are more self-sufficient and less dependent on external aid. This finding should alert us to the convenience of favouring early stage investments. This would imply changing the present composition of VC investments as they are primarily made up of late stage investments.

## 7. Conclusion

This paper has sought to identify the sequence in which patenting and VC investments take place. One possibility is that VC investments spur innovation; another is that firms patent before VC entry and VCs simply then exploit such innovations commercially. These two sequences have radically different implications in terms of economic policy. The former implies that VC should be seen as a valid financing source for innovation, while the second warns against it. To ascertain which sequence is prevalent, I have explored a unique self-collected dataset containing 164,486 controls and 119 VC-funded innovative firms which are highly representative of the whole population of high-tech firms that received VC investments between 2003 and 2005 in Spain. In the analysis I not only report estimates for the whole sample of VC-backed firms, but also for a finer breakdown by investment stage (early vs. late stage) and the ownership status of the VCs (public vs. private) in order to assess the effectiveness of different types of VC investments.

First, using a probit model, I find evidence that firms that have applied for at least one patent are significantly more likely to obtain VC investments. Next, using a matching approach to correct for any possible selection bias, I evaluate whether VCs really spur the innovative activity of the invested firms. Neither for the whole sample of VC-funded firms nor for the different sub-samples can I find evidence of a positive and significant impact of VC on firms' patenting activity. I do find evidence, however, that VC-funded firms have notably larger sales growth rates than non VC-backed firms, even after addressing selection. Thus, it seems that the sequence that best describes the relationship between VC and innovation is the second one: patenting takes place prior to VC entry and VCs mainly focus on the marketing phase. This main result is very robust and holds across the different sub-samples of VC-funded firms. Estimates for the different sub-samples, however, provide additional insights.

As for ownership, the analysis casts serious doubts on the design of Spain's public VC. Ideally, a proper public support program should be characterized by a notable "selection effect" and a reduced "treatment effect". I find precisely the opposite: the "selection effect" is very moderate while the "treatment effect" is sizeable. In particular, private VCs are notably more effective than public VCs at stimulating sales. Regarding the investment stage, I find early stage investments to be more effective at spurring sales growth rates than late stage investments. This finding highlights the convenience of shifting the current composition of investment stages, mostly dominated by late stage, in favour of early stage investments.

## Appendix. Variable definitions and further descriptive statistics

### Table A1: Variable definitions

**Dependent variables**

*Patent application dummy from t onwards:* dummy variable that takes value one if the firm patents from the exact moment of VC entry onwards.

*Patent application dummy from t+1 onwards*: dummy variable that takes value one if the firm patents after the first year following VC entry.

*Number of patent applications from t onwards*: number of patent applications that take place from the moment of VC entry onwards.

*Number of patent applications from t+1 onwards*: number of patent applications that take place after the first year following VC entry.

Sales growth rate: average sales growth rate of the two years following VC entry.

**Treatment variable**

*VC dummy:* dummy variable that takes value one if the firm receives the first VC investment at the corresponding year and zero otherwise.

**Pre-treatment variables used to estimate the propensity score**

*Age:* firms' age the year before VC entry.

*Cash flow:* firms' cash flow the year before VC entry.

*Exporter dummy:* dummy variable that takes the value one if the firm exports.

*Industry dummies:* set of 99 two-digit industry dummies (CNAE Rev. 2).

*Patent application dummy:* dummy variable that takes value one if the firm has applied for at least one patent (that has been subsequently granted) before VC entry.

*Private limited company dummy*: dummy variable that takes value one if the firm adopts the form of a private limited company and zero if it adopts the form of a limited liability corporation.

*Profits growth rate:* average profits growth rate in the two years preceding VC entry.

*Region dummies:* set of 50 province dummies.

*Sales growth rate:* average sales growth rate in the two years preceding VC entry.

*Time dummies:* set of yearly dummy variables.

*Total assets*: total assets of the firm in thousands of Euros.

*Workers*: number of employees in the firm.

**Other variables shown in the descriptive statistics**

Sales: firms' sales in thousands of Euros

Table A2. Descriptive statistics of all VC firms found in the SABI database

| | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Patent application | 213 | 0.10 | 0.37 | 0 | 3 |
| Number of Patents | 213 | 0.16 | 0.77 | 0 | 9 |
| Exporter dummy | 213 | 0.27 | 0.45 | 0 | 1 |
| Sales | 206 | 11,041.21 | 51,970.85 | 0 | 637,586 |
| Sales growth | 133 | 38.99 | 409.89 | -1 | 4,725 |
| Profits growth | 143 | 8.99 | 106.50 | -482 | 999 |
| Age | 213 | 8.61 | 11.78 | 1 | 85 |
| Workers | 198 | 68.60 | 297.09 | 0 | 3,964 |
| Total assets | 210 | 14,750.90 | 56,981.35 | 3 | 641,419 |
| Private limited company | 213 | 0.62 | 0.49 | 0 | 1 |
| Cash flow | 209 | 613.27 | 2,885.36 | -3,100 | 32,006 |

Table A3. Descriptive statistics of the VC firms included in the econometric analysis

| | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Patent application | 119 | 0.12 | 0.32 | 0 | 1 |
| Number of Patents | 119 | 0.23 | 0.94 | 0 | 9 |
| Exporter dummy | 119 | 0.39 | 0.49 | 0 | 1 |
| Sales | 119 | 10,284.66 | 20,921.84 | 0 | 142,596 |
| Sales growth | 119 | 3.70 | 21.11 | -1 | 223 |
| Profits growth | 119 | -0.31 | 16.40 | -96 | 68 |
| Age | 119 | 12.59 | 13.42 | 2 | 85 |
| Workers | 119 | 71.20 | 125.88 | 1 | 614 |
| Total assets | 119 | 11,424.46 | 18,857.31 | 6 | 99,223 |
| Private limited company | 119 | 0.52 | 0.50 | 0 | 1 |
| Cash flow | 119 | 564.96 | 1,385.04 | -3,100 | 6,915 |

Table A4. Descriptive statistics of all the available controls

| | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Patent application | 164,486 | 0.01 | 0.10 | 0 | 1 |
| Number of Patents | 164,486 | 0.02 | 0.22 | 0 | 27 |
| Sales | 164,486 | 2,511.01 | 10,350.85 | 0 | 775,008 |
| Sales growth | 164,486 | 0.99 | 43.86 | -56 | 9,139 |
| Profits growth | 164,486 | -0.28 | 15.67 | -1,825 | 1,676 |
| Age | 164,486 | 8.80 | 6.62 | 0 | 102 |
| Workers | 164,486 | 18.51 | 76.77 | 1 | 5,200 |
| Exporter dummy | 164,486 | 0.08 | 0.27 | 0 | 1 |
| Total assets | 164,486 | 1,772.83 | 6,631.46 | 0 | 256,711 |
| Private limited company | 164,486 | 0.87 | 0.34 | 0 | 1 |
| Cash flow | 164,486 | 127.38 | 1,012.47 | -193,798 | 51,956 |

Table A5. Descriptive statistics of the firms funded by public VCs

| | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Patent application | 66 | 0.06 | 0.24 | 0 | 1 |
| Number of Patents | 66 | 0.08 | 0.32 | 0 | 2 |
| Exporter dummy | 66 | 0.41 | 0.50 | 0 | 1 |
| Sales | 66 | 11,065.92 | 25,085.31 | 0 | 142,596 |
| Sales growth | 66 | 4.66 | 27.86 | -1 | 223 |
| Profits growth | 66 | -2.48 | 19.27 | -96 | 57 |
| Age | 66 | 13.47 | 15.80 | 2 | 85 |
| Workers | 66 | 63.08 | 117.39 | 1 | 561 |
| Total assets | 66 | 11,686.23 | 20,321.69 | 6 | 99,223 |
| Private limited company | 66 | 0.52 | 0.50 | 0 | 1 |
| Cash flow | 66 | 589.41 | 1,251.40 | -1,342 | 6,915 |

Table A6. Descriptive statistics of the firms funded by private VCs

| | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Patent application | 43 | 0.21 | 0.41 | 0 | 1 |
| Number of Patents | 43 | 0.49 | 1.49 | 0 | 9 |
| Exporter dummy | 43 | 0.37 | 0.49 | 0 | 1 |
| Sales | 43 | 9,826.77 | 15,713.61 | 0 | 72,566 |
| Sales growth | 43 | 1.81 | 4.16 | -1 | 23 |
| Profits growth | 43 | 3.27 | 12.61 | -17 | 68 |
| Age | 43 | 12.30 | 10.33 | 2 | 47 |
| Workers | 43 | 74.44 | 125.83 | 2 | 614 |
| Total assets | 43 | 9,885.28 | 15,821.34 | 206 | 91,404 |
| Private limited company | 43 | 0.56 | 0.50 | 0 | 1 |
| Cash flow | 43 | 657.95 | 1,515.62 | -1,338 | 5,407 |

Table A7. Descriptive statistics of the firms that receive early VC investments

| | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Patent application | 34 | 0.12 | 0.33 | 0 | 1 |
| Number of Patents | 34 | 0.12 | 0.33 | 0 | 1 |
| Exporter dummy | 34 | 0.29 | 0.46 | 0 | 1 |
| Sales | 34 | 4,324.82 | 9,983.53 | 0 | 43,715 |
| Sales growth | 34 | 9.89 | 38.39 | -1 | 223 |
| Profits growth | 34 | -1.55 | 19.20 | -66 | 57 |
| Age | 34 | 9.44 | 14.48 | 2 | 85 |
| Workers | 34 | 33.38 | 49.15 | 1 | 242 |
| Total assets | 34 | 6,947.29 | 17,579.86 | 204 | 99,223 |
| Private limited company | 34 | 0.53 | 0.51 | 0 | 1 |
| Cash flow | 34 | 101.79 | 1,447.28 | -3,100 | 6,915 |

Table A8. Descriptive statistics of the firms that receive late VC investments

| | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Patent application | 71 | 0.11 | 0.32 | 0 | 1 |
| Number of Patents | 71 | 0.30 | 1.19 | 0 | 9 |
| Exporter dummy | 71 | 0.48 | 0.50 | 0 | 1 |
| Sales | 71 | 14,672.85 | 25,256.30 | 0 | 142,596 |
| Sales growth | 71 | 0.66 | 1.62 | -1 | 9 |
| Profits growth | 71 | -0.93 | 15.57 | -96 | 68 |
| Age | 71 | 15.82 | 13.18 | 2 | 62 |
| Workers | 71 | 92.66 | 141.41 | 2 | 614 |
| Total assets | 71 | 14,462.35 | 19,368.26 | 483 | 97,403 |
| Private limited company | 71 | 0.46 | 0.50 | 0 | 1 |
| Cash flow | 71 | 849.35 | 1,258.84 | -1,342 | 5,407 |

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