Venture Capital Investments in Europe and Portfolio Firms' Economic Performance: Independent versus Corporate Investors

Massimo G. Colombo

Politecnico di Milano. Department of Management, Economics and Industrial Engineering.

Via R. Lambruschini, 4/b - 20156, Milan, Italy.

Email: massimo.colombo@polimi.it. Ph.: +39 02 23992748.

Samuele Murtinu

Università Cattolica del Sacro Cuore. Institute of Economic Policy.

Largo A. Gemelli 1 - 20123, Milan, Italy.

Email: samuele.murtinu@unicatt.it. Ph.: +39 02 72342696.

Abstract

Using a new European Commission-sponsored longitudinal dataset – the VICO dataset – we assess the impact of independent (IVC) and corporate venture capital (CVC) investments on the economic performance of European high-tech entrepreneurial firms during the period 1992-2010. After controlling for potential sources of endogeneity and selection bias, our results indicate that both IVC and CVC investments boost portfolio firms' economic performance. These effects are mostly due to an increase in real sales value. Moreover, the dynamics of the impact of VC investments on firms' overall economic performance and its components – real sales value, real fixed assets, and real labor costs – differs depending on the type of investor. Finally, we do not detect any impact related to the syndication of investments by both IVC and CVC investors.

Keywords: independent venture capital, corporate venture capital, high-tech entrepreneurial firms, economic performance, syndication, Europe

JEL Classification: G24, D24, M13, C23

1. Introduction

Venture capital (VC) is considered to be one of the most suitable financing modes for young high-tech entrepreneurial firms to raise external capital (e.g. Denis, 2004; Gompers et al., 2009; Gompers and Lerner, 2001, 2004). However, VC investors (VCs) are heterogeneous and differ along several dimensions. One of the most important dimensions of heterogeneity among VCs is the type of *ownership and governance* (Bertoni et al., 2015; Da Rin et al., 2013; Dimov and Gedajlovic, 2010; Gompers et al., 2009), because of its strong influence on VCs' objectives and investment behavior, and on the value investors can add to portfolio firms.[1] In this paper, we focus on *independent* and *corporate* VCs (IVCs and CVCs), the two VC types that have attracted most scholarly attention. To the best of our knowledge, no previous study has examined the impact of these two types of VC investments on portfolio firms' *overall economic performance*. This is a relevant gap because reliance on output measures – like innovation and sales growth – gives a partial and incomplete view of portfolio firms' performance.

As we will explain in detail in the next section, while IVCs aim at seeking capital gains on behalf of their limited partners, CVCs typically pursue strategic objectives in addition to financial objectives (Gompers, 2002; Gompers and Lerner, 2000; Hellmann, 2002). Moreover, CVCs provide portfolio firms with access to the valuable complementary assets possessed by their parent company (Dushnitsky, 2012). A growing body of literature has compared the impact of IVC and CVC investments on portfolio firms' innovation (Chemmanur et al., 2014; Park and Steensma, 2013),

[1] Traditional independent VC firms manage pools of funds aimed at investing in promising companies. VC managers define a business plan highlighting the type of entrepreneurial firms they are looking for, and show such business plan to potential investors on the market (e.g. banks, pension funds, hedge funds, insurance companies, university endowments, wealthy individuals, family offices). Once they raise sufficient capital to start-up the fund, they screen the market to find promising young companies. If these latter sell an ownership stake to the VC firm and give the VC firm a seat on the board of directors, they become portfolio companies. The final goal of traditional VC firms is to either sell the portfolio company to another firm or take it public in an initial public offering (IPO). The money raised by exiting the investment pays back the investment and could give additional profits.

growth (Bertoni et al., 2013), and the likelihood of going public (Gompers and Lerner, 2000; Ivanov and Xie, 2010; Park and Steensma, 2012).

In this paper, we adopt the overall economic performance metric to get a more comprehensive assessment of the relative economic impact of IVC and CVC investments on portfolio firms. Moreover, we explore the *dynamics* of the performance impact of IVC and CVC investments over time, and the *channels* through which this impact materializes. As to the former point, we distinguish between the short-term impact of VC investments (i.e., in the first two years after the first VC investment round) and the long-term impact (i.e., in the period starting from the third year after the first VC investment round). As to the latter point, the overall economic performance of portfolio firms can be increased through two fundamentally different channels. An output-side performance increase occurs when a firm manages to increase its real sales value – e.g., through a better commercialization strategy or the entry into new geographical markets – without a corresponding increase of production factors. An input-side performance increase occurs through a more efficient use of production factors, e.g., when production processes are reengineered. Lastly, we compare the impact on portfolio firms' overall economic performance of investments syndicated by IVCs and CVCs with that of IVC and CVC investments. To the best of our knowledge, no previous study has examined the performance impact of mixed IVC-CVC syndicates, in spite of the diffusion and conceptual interest of this form of VC investment.

To address these research questions, we use a sample of European high-tech VC-backed entrepreneurial firms observed in the period 1992-2010, and we compare them with a matched sample of twin non-VC-backed firms. Data on both VC-backed and non-VC-backed firms are drawn from a new longitudinal firm-level dataset - the VICO dataset, that was built by the 7th Framework Program VICO project promoted by the European Commission (http://www.vicoproject.org/). As is well known, there is low coverage by commercial databases (e.g., the Thomson One database) of VC investments in Europe, especially those conducted by non-independent VC investors (Cumming et al., 2014; Da Gbadji et al., 2014). Moreover, using the VICO dataset avoids misreporting the VC investment types, which plagues many studies based on commercial datasets (Ivanov and Xie, 2010: p. 135. See also Cumming et al., 2014). To control for selection bias, we follow Chemmanur et al. (2011), and estimate a fixed effects (FE) regression with "leads". Further, to test the robustness of our main results we use an instrumental variables (IV) approach. Finally, we implement i) the tests developed by Chetty et al. (2011) to assess the correlation between VC variables and variables omitted from our models, which are likely to be correlated with firms' overall economic performance and might drive our results; and ii) the test developed by Altonji et al. (2000) to estimate the maximum amount of selection on unobservables that can exist to reliably interpret our results.

This paper offers three original contributions to the literature. First, we show that both IVC and CVC investments have a large positive impact on portfolio firms' overall economic performance: the estimated magnitude of the performance increase attributable to IVC and CVC investments is +41% and +50%, respectively. Conversely, investments syndicated by both IVCs and CVCs do not lead to any increase in portfolio firms' performance.

The second contribution of this work is the investigation of the *dynamics* of the portfolio firms' performance improvements. Our results show that the short-term performance impact of IVC investments is positive: its estimated magnitude is +26%. The short-term impact of CVC investments, while similar in magnitude to that of IVC investments, is not statistically significant. In the long term, both IVC and CVC investments have a statistically significant and economically relevant effect on portfolio firms' overall economic performance (+58% and +67%, respectively).

The third contribution is the inspection of the *channels* through which IVC and CVC investments improve the portfolio firms' overall economic performance. Our results show that the performance improvements engendered by both IVC and CVC investments are mostly attributable to the output side: the estimated long-term effects on real sales growth are equal to +67% and +58%, respectively. IVC investments also result in a significant short-term real sales increase (+36%), which is larger than the short-term real sales increase engendered by CVC investments (+18%). This result is in line with previous studies that found that IVC investors accelerate the sales growth of their portfolio firms (Bertoni et al., 2013; Hellmann and Puri, 2000). As to the input side, we highlight an important difference between IVCs and CVCs. IVC backing leads to an increase of headcount and real payroll expenses, whose magnitude is smaller than that of the increase in real sales value. Moreover, such increases materialize in the short term (+21% and +19%, respectively), while after the second year from the first VC round, we do not record any additional effect of IVC on headcount and real payroll expenses. No impact on real fixed assets is observed. As to CVC investments, we do not observe any significant effects on real payroll expenses, headcount and real fixed assets neither in the short term nor in the long term.

The paper is structured as follows. In Section 2, we review the extant literature. Section 3 illustrates the construction of the dependent variable and the empirical methodology. Section 4 describes the VICO dataset and the sample used in the empirical analysis, and provides some basic summary statistics. Section 5 reports the results and several robustness checks. Section 6 concludes.

2. Literature Review

Several studies have documented a positive impact of VC on portfolio firms' performance in terms of innovation (Bertoni and Tykvova, 2015; Kortum and Lerner, 2000), growth (Bertoni et al. 2011; Puri and Zarutskie, 2012), overall economic performance (Chemmanur et al., 2011; Croce et al., 2013), and the likelihood of going public (Chemmanur et al., 2010; Cumming et al., 2014; Giot and Schwienbacher, 2007; Puri and Zarutskie, 2012). VCs contribute to the success of portfolio firms in several ways. First, VCs provide the financial resources that portfolio firms lack due to capital market failures (Amit et al., 1998).[2] Second, VCs "coach" portfolio firms, providing added value in areas where these firms lack internal expertise, as the recruitment of managers and other skilled personnel (Colombo and Grilli, 2013; Hellmann and Puri, 2002) and strategic planning (Gorman and Sahlman, 1989). Third, VCs provide high-powered incentives for entrepreneurs (e.g. through staging) and closely monitor their activities (Dihiya and Ray, 2012; Gompers, 1995; Kaplan and Strömberg, 2003, 2004; Lerner, 1995; Tian, 2011; Wang and Zhou, 2004). Finally, VCs help portfolio firms establish alliances with valuable partners (Colombo et al., 2015; Hochberg et al., 2007; Hsu, 2006; Lindsey, 2008).

However, as was mentioned earlier, VCs have different *ownership and governance* structures which influence their objectives, investment behavior and the support they may provide to portfolio firms (Bertoni et al., 2015; Da Rin et al., 2013; Dimov and Gelajdovic, 2010; Gompers et al., 2009). Therefore, the impact of VC investments on portfolio firms may well differ depending on the type of VC investor. Here we consider IVCs and CVCs and their expected impact on the overall economic performance of portfolio firms.

IVC represents the most traditional and developed form of VC, in the U.S. and abroad (Kovner and Lerner, 2015). IVCs manage several pools of capital provided by various sources (e.g., banks, pension funds, hedge funds, insurance companies, university endowments, wealthy individuals, family offices). Each pool is generally organized as a legally separate limited partnership, with a management company serving as the general partner and capital providers serving as limited partners (Sahlman, 1990). The salaries of IVC managers largely depend on carried interest. Moreover, IVCs

[2] Young high-tech entrepreneurial firms face serious difficulties in raising capital from banks and other traditional financial institutions (Berger and Udell, 1998; Carpenter and Petersen, 2002; Denis, 2004) because of the technology-intensive nature of their activity, highly variable and skewed returns, asymmetric information (e.g., lack of a consolidated track record) and a lack of collateral - i.e., assets are firm-specific and/or intangible. It is worth noting that we use the term "market failures" and not "market imperfections". As explained by Stiglitz (1989), there is some controversy over whether financial market imperfections are real imperfections or a rational way for the markets to work. We are grateful to an anonymous reviewer for this suggestion.

need to raise new capital on a regular basis, often from the same investors. Therefore, the main objective of IVCs is to realize the greatest possible internal rate of return (IRR), i.e. a conspicuous capital gain in the shortest possible time (Cumming et al., 2005).

CVCs are structured as investment vehicles owned by a non-financial company. The parent company provides capital and other tangible and intangible resources, and it influences investment decisions (Dushnitsky, 2012; Gompers and Lerner, 2000). In the last 15 years, CVC has played a crucial role in the overall VC market in the US.[3] From 1995 to 2011, CVC funds participated in 15.8% of total VC deals and accounted for more than 8% of the total amount of VC in the US (source: http://www.pwc.com/us/en/technology/moneytree.jhtml). Some recent examples of CVC strategies are the investments made by Facebook, Zynga and Amazon in entrepreneurial social media firms or those made by Google Ventures in internet, biotech and clean-tech companies. CVC is also widely diffused outside the US (Bottazzi et al., 2008; Da Gbadji et al., 2014).

CVCs have specific objectives, resources and capabilities, which differ from those of IVCs. Thus their contribution to the portfolio firms' performance is also likely to differ. CVCs often pursue strategic objectives in addition to or even in substitution of financial objectives, most notably the opening of a "window" on the development of promising new technologies related to the core business of the parent company (Dushnitsky and Lenox, 2005a,b) and the identification of potential acquisition targets (Benson and Ziedonis, 2009). These objectives may conflict with those of the portfolio firms, as shown in the model developed by Hellmann (2002). In this model, a venture chooses between an IVC investor and a CVC one, who compete to fund the venture. The choice of

[3] In February 2012, Mark Heesen, president of the US National Venture Capital Association (NVCA), declared that "Corporations bring a unique and specialized perspective to venture investing and are increasingly becoming more active in supporting the growth of emerging technologies. In turn, the venture capital industry has embraced the CVCs' depth of resources – including R&D, access to broad marketing channels and operating experience – as invaluable contributions to the success of the startup economy". Source: http://www.pwc.com/us/en/press-releases/2012/q4-2011-corp-vc-press-release.jhtml. It is worth noting that CVC dates back to the 1960s. For more details on the origins of CVC, see Gompers and Lerner (2000).

the venture depends on the strategic fit between its technology and the technology of the parent organization of the CVC fund (Wadhwa et al., 2015). If the two technologies are complementary, the venture will choose the CVC investor. If the technologies are substitutes and the venture's technology is not a threat to the parent organization's profits, the venture will choose the IVC investor. In case of a strong threat, IVC and CVC investors will syndicate the deal. The key point is that when technologies are complementary, CVCs have a competitive advantage over IVCs in providing value to portfolio companies. Instead, when technologies are substitutes, there is a trade-off between the strategic and financial objectives of CVCs. As the strategic objectives of CVCs conflict with those of the venture, CVC investments may well have detrimental effects on portfolio firms. Riyanto and Schwienbacher (2006) extend the model and assume that the degree of complementarity increases with CVC financing. Fulghieri and Sevilir (2009) add product market competition, and claim that CVCs have a competitive advantage when R&D competition is high.

As regards resources and capabilities, CVCs may engender benefits that cannot be provided by IVCs.[4] In fact, CVC-backed firms may obtain access to the specialized resources and capabilities of the parent organization of the CVC investor (e.g. distribution channels, sales force, brand, production capacity, complementary technological competencies). In addition, portfolio firms can benefit from the network of industry-specific contacts with potential customers and suppliers of the parent organization. However, CVCs may also suffer from organizational deficiencies (Dushnitsky and Shapira, 2010), which are likely to render their coaching and monitoring capabilities less effective than those of IVCs. First, early stage financing of young high-tech entrepreneurial firms is the core business of IVCs, while it is an ancillary activity for the parent company of the CVC program.

[4] An example refers to the recent investments of Google Ventures in healthcare companies. Google Ventures President Bill Maris has claimed that "Every time you talk to Siri, or use Google Maps, you are using a form of artificial intelligence. The same technology could be used in many healthcare applications, such as analyzing cancer patient data and recommending more effective treatments" (source: http://www.fiercebiotech.com/tags/google-ventures).

Therefore, CVCs benefit from learning economies to a less extent than IVCs. Second, because of the difficulty of finding an appropriate performance metric that reflects the mix of financial and strategic objectives of CVCs and the inclination of their parent companies to maintain pay equality to avoid resentment from personnel in other business units, it is rather difficult for the parent companies of CVCs to attract highly qualified investment managers. In sum, we expect the different ownership and governance of IVCs and CVCs to influence the intensity and the quality of the value-enhancement activities that IVCs and CVCs perform to the advantage of portfolio firms and, finally, their impact on the overall economic performance of these firms.

A final comment is in order. CVCs often form syndicates with IVCs.[5] In addition to allowing a more precise screening of investment targets (Casamatta and Haritchabalet, 2007; Lerner, 1994), syndication might have a beneficial effect on portfolio firms' performance, because it allows the combination of the financial and non-financial resources of syndicate members and closer monitoring of portfolio firms (Brander et al., 2002; Cumming and Walz, 2010, Tian, 2012). However syndication also entails agency and transaction costs (Cumming et al., 2007; Wright and Lockett, 2003). As highlighted by Chahine et al. (2012: p. 180), syndicate members may "have different objectives which can result in principal-principal conflicts of interests among members of a VC syndicate". Because IVCs and CVCs often have different objectives, these conflicts are likely in mixed IVC-CVC syndicates. Therefore, whether backing by mixed IVC-CVC syndicates leads to superior overall economic performance of portfolio firms is an open issue that waits for empirical evidence.

[5] According to Katila et al. (2008), 84% of CVC rounds are syndicated with (at least) an IVC investor. In the Survey of Corporate Venture Capital in 2007 (MacMillan et al., 2008), conducted by the National Venture Capital Association (NVCA) in partnership with the Wharton School and the MIT Sloan School, 98% of the 48 surveyed CVC organizations report that they invest in syndicates. Often, such syndicated investments are with IVC investors.

3. The Identification Strategy

3.1 Dependent variable

Measuring entrepreneurial firms' overall economic performance is empirically non-trivial. Here, we follow the procedure suggested by Croce et al. (2013). Such procedure requires the estimation of industry-specific firm-level production functions allowed to drift over time, whose inputs may be subjected to endogeneity, adjustment costs, and unobserved heterogeneity, i.e. firms choose the inputs on the basis of their own level of productivity, leading to a correlation between inputs and the error term. Production functions are estimated by means of General Methods of Moments (GMM). Mairesse and Hall (1996) show that the use of a GMM method based on first-differenced equations (Arellano and Bond, 1991) produces biased estimates, leading to a downward bias in the estimation of the coefficient of capital. A method based on a system of both first-differenced and level equations (Arellano and Bover, 1995) yields more precise estimates (Bond and Van Reenen, 2007).

In this work, we use the GMM system method developed by Blundell and Bond (2000), which solves the problems related to the weak correlations between the current growth rates of a firm's real sales value, fixed assets and payroll expenses, and the lagged levels of these variables. More specifically, we model a series of industry-specific firm-level Cobb-Douglas production functions with a first-order autoregressive component in the error term, where the coefficient of the autoregressive component must be lower than one to ensure stationarity to the model. We use real sales value as output variable, and its logarithm as dependent variable. As inputs, we use the logarithm of real payroll expenses and the logarithm of real fixed assets. The arguments of the logarithmic functions for the output and input variables are augmented by one. The output and input variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat).[6] This way,

[6] Several studies (e.g., Katayama et al., 2009) highlight the methodological problems in using country-level (and industry-level) deflators for firm-level sales value and inputs in traditional production function estimates (De Loecker, 2007). As suggested by Van Beveren (2012: p. 103): 'the omitted output price bias will only arise if industry-level price deflators

the deflated values may be considered as (admittedly rough) proxies of their quantities. In the estimation of each industry-specific firm-level production function, we include a vector of year dummies. Moreover, as suggested by Blundell and Bond (2000), lagged instruments start from the period *t-3* (*t-2*) for instruments in levels (differences): current values of real sales, fixed assets and payroll expenses might be correlated with productivity shocks in the periods *t*, *t-1* and *t-2*. The residuals of every production function are our measure of overall economic performance (Van Biesebroeck, 2007). For more details on the estimation procedure of our overall economic performance measure, see Croce et al. (2013: Appendix A).

It is worth noting that our dependent variable is not a measure of total factor productivity (TFP) *strictu sensu*. In fact, there are two main reasons why the residuals from the Cobb-Douglas regression models cannot be regarded as measures of TFP: i) the estimated Cobb-Douglas functions exhibit variable returns to scale (see Table A.1 in the Appendix); and ii) the deflated values we use in the empirical model (real sales value, fixed assets, and payroll expenses) cannot be considered as quantities.[7] In other words, the procedure we use here - and used by several other studies (see e.g.,

are used and firm-level prices deviate from these deflators'. But this latter assumption cannot be tested, unless a researcher has information on firm-level prices. Moreover, Van Beveren (2012: p. 104) claims that: 'A formal solution for the bias induced by firm-specific input prices (in the absence of firm-level price data) has yet to be introduced'. In our dataset, these problems are somehow less dramatic than in other studies, for several reasons. First, our sample is more homogeneous than other samples composed of large and small firms, old and young firms, single-product and multi-product firms, etc. Second, in the six countries included in our study in the period under consideration (see Figures A.1 A.2, and A.3 in the Appendix) the consumer price index and the labor cost index - proxied by the total cost on an hourly basis of employing labor - show a similar evolution over time. Instead, the cost of capital - proxied by the central government bond yields on the secondary market, gross of tax, with a residual maturity of around 10 years - declined over time. However the coefficient of capital in the estimation of our industry-specific firm-level production functions is always much lower than the coefficient of labor (see Table A.1 in the Appendix). So, the bias introduced when using the same country-level deflator for firm-level sales value and inputs should be not so exacerbated as in studies dealing with highly capitalized firms.

[7] Starting from Solow (1957), the literature on TFP estimation is vast. For a recent review about methodological issues (i.e., simultaneity bias, attrition, omitted price bias, endogeneity of product choice), see Van Beveren (2012). See also Van Biesebroeck (2007) for an illustration of the strengths and weaknesses of the most popular (parametric, semi-parametric and nonparametric) techniques used to estimate productivity. For more recent and advanced techniques, see Ackerberg et al. (2006), De Loecker (2007), Katayama et al. (2009) and Wooldridge (2009), among others.

Croce et al., 2013 and the literature cited there) - does not collapse to a proper output quantity index divided by a proper input quantity index.[8]

3.2 The model specification

As highlighted by Gompers and Lerner (2001), the causality between VC funding and portfolio firms' performance is not so straightforward. In other words, VC-backed firms may show a higher performance than non-VC-backed firms even before the first VC investment, i.e. there may be a positive selection bias.

Taking inspiration from Chemmanur et al. (2011), the impact of IVC, CVC and IVC-CVC syndicated investments on portfolio firms' overall economic performance is investigated using the following panel data model:

$$OEP_{i,t} = \alpha_0 + \alpha_1 A_{i,t} + \alpha_2 Age_{i,t} + \beta_1 IVC_{i,t}^{PRE} + \beta_2 IVC_{i,t}^{POST} + \beta_3 CVC_{i,t}^{PRE} + \beta_4 CVC_{i,t}^{POST} + \beta_5 CVCSYND_{i,t}^{PRE} + \beta_6 CVCSYND_{i,t}^{POST} + \gamma_t + \eta_i + \varepsilon_{i,t}; \quad (1)$$

where $OEP_{i,t}$ is the overall economic performance of firm i at time t, $A_{i,t}$ is the logarithm of real total assets of firm i at time t, $Age_{i,t}$ is the logarithm of the number of years since the firm i's foundation at time t, γ_t is a vector of year dummies, η_i is a firm-specific unobserved effect, and $\varepsilon_{i,t}$ is an i.i.d. error term. The arguments of the logarithmic functions of $A_{i,t}$ and $Age_{i,t}$ are augmented by one. $IVC^{PRE}_{i,t}$ is a dummy variable that is equal to 1 for IVC-backed firms in years $t-1$ and t, with t representing the year in which the focal firm received its first VC investment, and 0 otherwise. $IVC^{POST}_{i,t}$ is a dummy variable that is equal to 1 for IVC-backed firms from the year after the first VC investment onwards, and 0 otherwise. Similarly, $CVC^{PRE}_{i,t}$ and $CVC^{POST}_{i,t}$, and $CVCSYND^{PRE}_{i,t}$ and $CVCSYND^{POST}_{i,t}$ are the corresponding dummies for CVC-backed firms and firms backed by a mixed IVC-CVC syndicate, respectively. As is common in the VC literature, $IVC^{POST}_{i,t}$, $CVC^{POST}_{i,t}$, and $CVCSYND^{POST}_{i,t}$ do not

[8] We are grateful to an anonymous reviewer for raising this issue.

switch back to 0 when the VC investors exit the portfolio firm's equity (e.g., Chemmanur et al., 2011; Croce et al., 2013; Cumming et al., 2014; Hsu, 2004; Puri and Zarutskie, 2012). We estimate equation (1) using a fixed effects (FE) regression with robust standard errors clustered at the firm level. The FE estimation removes all time-invariant unobserved heterogeneity; moreover, the "leads" ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$) control for selection effects. Note that in Section 5.2, we also re-estimate equation (1) through an instrumental variables (IV) methodology to test the robustness of our main results. Moreover, in Section 5.3 we implement additional tests to check the robustness of our results in the light of unknown selection. More precisely, we implement: i) the tests developed by Chetty et al. (2011) to assess the correlation between the VC variables and variables omitted from our models, which are likely correlated with firms' overall economic performance, and ii) the test developed by Altonji et al. (2000) to estimate the maximum amount of selection on unobservables that can exist to get a reliable interpretation of our results.

Equation (1) can be easily augmented to study the dynamics of the impact of IVC, CVC and IVC-CVC syndicated investments. For this purpose, we substitute $IVC^{POST}_{i,t}$, $CVC^{POST}_{i,t}$ and $CVCSYND^{POST}_{i,t}$ with two sets of dummies that distinguish the first two years after the first VC investment ($IVC^{POST\_SHORT}_{i,t}$, $CVC^{POST\_SHORT}_{i,t}$ and $CVCSYND^{POST\_SHORT}_{i,t}$) from the period starting from the third year after VC funding ($IVC^{POST\_LONG}_{i,t}$, $CVC^{POST\_LONG}_{i,t}$ and $CVCSYND^{POST\_LONG}_{i,t}$). We then estimate the following model:

$$OEP_{i,t} = \alpha_0 + \alpha_1 A_{i,t} + \alpha_2 Age_{i,t} + \beta_1 IVC^{PRE}_{i,t} + \beta_2 IVC^{POST\_SHORT}_{i,t} + \beta_3 IVC^{POST\_LONG}_{i,t} + \beta_4 CVC^{PRE}_{i,t} + \beta_5 CVC^{POST\_SHORT}_{i,t} + \beta_6 CVC^{POST\_LONG}_{i,t} + \beta_7 CVCSYND^{PRE}_{i,t} + \beta_8 CVCSYND^{POST\_SHORT}_{i,t} + \beta_9 CVCSYND^{POST\_LONG}_{i,t} + \gamma_t + \eta_i + \varepsilon_{i,t}. \quad (2)$$

Finally, along the lines of Chemmanur et al. (2011), we estimate three models with the same specification as the one in equation (2), in which the dependent variables are the logarithms of real sales value, fixed assets, and payroll expenses, respectively. The arguments of the logarithmic functions are again augmented by one. The aim is to inspect the channels through which IVC, CVC and IVC-CVC syndicated investments allegedly improve the portfolio firms' overall economic performance. For the sake of completeness, we also estimate a fourth model related to the number of employees. In this case, the purpose is to investigate whether the effects (if any) of VC investments on the dynamics in labor inputs – as reflected by payroll expenses – were mainly due to a change in either the number of employees or the unit labor cost as a proxy of personnel's quality (or in both variables).

4. The Data

4.1 The VICO dataset

The VICO dataset[9] includes data on 759 VC-backed and 7,611 non-VC-backed high-tech entrepreneurial firms that are located in seven European countries (i.e., Belgium, Finland, France, Germany, Italy, Spain, and the United Kingdom), were less than 20 years old in 2010, were independent at their founding date (i.e., not controlled by other business organizations), and operate in high-tech manufacturing and services industries: nanotechnology, biotechnology, pharmaceuticals, computers, electronic components, telecommunications equipment, precision, optical and medical instruments, robotics, aerospace, software, telecommunications services, internet and multimedia services, web publishing, renewable energies, R&D and engineering services. As explained in Bertoni and Martí (2011: p. 5), non-VC-backed firms are potential investees. In fact, these latter were included in the VICO dataset following the same criteria (country, age, independence, industry) used for the inclusion of the VC-backed firms. Moreover, given that the number of non-VC-backed firms in the VICO dataset is 10 times larger than the number of VC-backed firms, it is possible to perform a

[9] For a comprehensive description of the VICO dataset and detailed information on the procedures and sources used in the data-gathering process and on all of the portfolio firm-, investment-, and investor-level variables included in the dataset, see Bertoni and Martí (2011).

matching procedure to compare the VC-backed firms with the 'most similar' potential investees (for more details, see Section 4.2). Both surviving and non-surviving firms (i.e., firms that ceased operations or were acquired) are included in the dataset, and therefore, concerns with respect to a potential survivorship bias are alleviated.[10] Firms in the dataset are observed from the foundation date up to 2010 (or to the time they ceased operations or were acquired).

Data related to VC-backed firms were collected via random extraction from commercial databases (i.e., Thomson One, VC-PRO, and Zephyr) and country-specific proprietary datasets, including the yearbooks of the Belgium Venture Capital Association and the Finnish Venture Capital Association, the ZEW Foundation Panel (Germany), the Research on Entrepreneurship in Advanced Technologies (RITA) directory and Private Equity Monitor (Italy), the Web Capital Riesgo Database (Spain), and the Library House, which is now called Venture Source (the UK). Moreover, the data were cross-checked with those available from public sources (e.g., websites and annual reports of VC investors, press releases and press clippings, and initial public offering prospectuses). A central data collection unit ensured that the information was consistent across countries. This data collection process ensures that the VICO dataset offers a more accurate coverage of VC investments in Europe than the one provided by available commercial databases. The VC-backed firms included in the VICO dataset received their first investment in the period 1994-2004 and were less than ten years old at the time of the first VC investment. As is common in the VC literature, the VICO dataset does not include

[10] This notwithstanding, in unreported regressions, we test whether our main results (shown in Table 3) are driven by the presence of survivorship bias. In comparison to non-VC-backed firms, low-performing VC-backed firms are less likely to go bankrupt while high-performing VC-backed firms are more likely to be acquired. This might generate a downward selection bias in the estimates of the effect of VC backing on portfolio firms' overall economic performance. The VICO dataset enables us to apply the test proposed by Semykina and Wooldridge (2010). More specifically, we estimate the model specifications shown in Table 3, augmented by the inclusion of a time-varying inverse Mills ratio (IMR)-type term (for a similar procedure, see Grilli and Murtinu, 2014, 2015). This latter is computed from a series of yearly probit models, in which the dependent variable is the firms' likelihood to exit the dataset, because of liquidation or loss of independence (i.e., acquisition). In all regressions, the coefficient of the IMR-type term is not statistically significant at conventional confidence levels, and so the null hypothesis of the absence of survivorship bias is not rejected. The results are available upon request from the authors. We are grateful to an anonymous reviewer for this suggestion.

leverage buy-outs (LBOs), real estate, distressed debt funds and other private equity investments. The non-VC-backed firms were randomly extracted (conditional on the criteria reported above) from all available vintage years of Bureau van Dijk's Orbis database. Therefore, as is the case for VC-backed firms, the VICO dataset includes both surviving and non-surviving non-VC-backed firms. Also in this case, other sources were used to improve the coverage of the dataset, such as industry associations and Chambers of Commerce directories, commercial firm directories, Zephyr, Creditreform, the ZEW Foundation Panel, and the RITA directory. Accounting data and data on employment for both VC-backed and non-VC-backed firms were obtained from the Orbis database.

4.2 The sample

We classified the IVC- and CVC-backed firms according to the identity of the VC investor that provided the first VC investment, independently from the identity of the VC investor(s) that eventually invested in subsequent VC rounds. Following the CVC literature (e.g., Ivanov and Xie, 2010), we defined a CVC-backed firm as a firm that received an initial CVC investment, potentially syndicated by one or more IVCs. Conversely, an IVC-backed firm received an initial IVC investment, potentially syndicated by other IVCs. We excluded VC-backed firms that received a first investment by other types of VCs (i.e., bank-controlled VCs and governmental VCs) or by VCs that had a missing name, address and/or contact information in the VICO dataset. Moreover, we excluded both VC-backed and non-VC-backed firms whose data on input (payroll expenses and fixed assets) and output (sales value) variables were not available. Due to the lack of accounting data for most German firms, all German firms were excluded from the study.

Separately for IVC- and CVC-backed firms, we randomized our dataset and used a one-to-one propensity score matching methodology without replacement to match each VC-backed firm in the year of the first VC investment with a twin non-VC-backed firm. Matching procedures are well established in the VC literature (Chemmanur et al., 2011; Croce et al., 2013; Grilli and Murtinu, 2014; Megginson and Weiss, 1991; Puri and Zarutskie, 2012; Tian, 2012). Following Dehejia and Wahba

(2002), we chose a matching procedure without replacement due to the large number of non-VC-backed firms included in the VICO dataset. The propensity scores were obtained through two probit models. The set of independent variables includes firm age, total assets, country and industry dummies. We used the same model specification of Puri and Zarutskie (2012), with the only difference being that we used European countries (and not US regions) as geographical controls. The two matching procedures passed the balancing and reliability tests suggested by Dehejia and Wahba (2002).[11]

The sample used in this work includes 215 IVC-backed firms and 44 CVC-backed firms, out of which 18 firms received an initial investment syndicated by both IVC and CVC investors. In the rest of the paper (as also introduced in Section 3.2), CVC-backed firms that received an initial VC investment from an IVC-CVC syndicate are labeled as "CVCSYND-backed" firms,[12] while firms that received an initial VC investment by a CVC investor not syndicated with any IVC investor are classified as "CVC-backed" firms.[13]

In Table 1, we report some descriptive statistics (means and standard deviations in Panel A; medians in Panel B) about the components of the overall economic performance (real sales value, fixed assets, and payroll expenses) and the number of employees (see Section 3.1), and total assets for the VC-backed (IVC-, CVC-, and CVCSYND-backed) and matched non-VC-backed firms

[11] More specifically, we refer to: i) the t-tests for the equality of means for all covariates used in the matching procedures before and after matching; ii) the comparison between the pseudo R^2 obtained by estimating the probit models on the matched samples and those obtained before matching; and iii) the comparison between the p-values of the LR test on the joint insignificance of covariates used in the matching procedures before and after matching. The estimates of the two probit models and the results of the tests are available upon request from the authors.

[12] Our definition of syndication closely adheres to the definition provided by Tian (2012: pp. 249-250). Given that our analysis is not at round level, we assume that IVC and CVC investors syndicate when they invest in the same portfolio firm in the same year (see Brander et al., 2002, for the same criterion).

[13] Note that firms classified as IVC-backed (CVC-backed) may have received investments from CVCs (IVCs) in subsequent rounds. Even if this event occurs, they continue to be classified as IVC-backed (CVC-backed) firms, that is they do *not* switch to the CVCSYND-backed category.

included in our sample. For the VC-backed firms, we also show the corresponding statistics in the years before and after the first VC investment.

As a general remark, standard deviations are quite high, especially in the non-VC-backed control sample, making mean values less informative. VC-backed firms, when they are observed in the period before the first VC investment, generally exhibit smaller median values than non-VC-backed firms, with the exception of real fixed assets (and of real total assets for CVCSYND-backed firms). The opposite applies when VC-backed firms are observed in the post-investment period, in line with the view that VC is instrumental in scaling up firms' operations. As to VC-backed firms, in the pre-investment period CVC-backed firms have larger median values of all variables than IVC- and CVCSYND-backed firms (again with the exception of the large median value of total assets of CVCSYND-backed firms). In the post-investment period, there is no clear difference between IVC-, CVC, and CVCSYND-backed firms. From before to after the first VC investment, there are substantial increases in the values of real sales, fixed assets, payroll expenses, and headcount for all types of VC-backed firms.

[Table 1 about here]

In Table 2, we report the results of a simple univariate analysis to assess the change in the overall economic performance of the three categories of VC-backed firms under consideration here: IVC-, CVC-, and CVCSYND-backed firms. We compare their average overall economic performance before (column I) and after (column II) the first VC investment. For each category, column III shows the Wald test on the difference between the mean overall economic performance in the years before and after VC funding. After VC-backing, the overall economic performance of VC-backed firms increases, but the increases are significant (at 1%) and of large economic magnitude (+28.2% and +40%) only for IVC- and CVC-backed firms. The differences in the overall economic performance in the years before VC funding among IVC-backed, CVC-backed, and CVCSYND-backed firms are not statistically significant.

[Table 2 about here]

5. Results

5.1 Regression analyses

The results of the estimates are illustrated in Table 3. In columns I and II, we show the estimates of equations (1) and (2). In columns III, IV, V and VI, we report the estimates of equation (2) related to sales value, fixed assets, payroll expenses and headcount, respectively. After considering the selection effect, the estimates reported in column I indicate that both IVC and CVC investments have a positive impact (significant at 1%) on the portfolio firms' overall economic performance. The estimated increase in the level of overall economic performance attributable to VC-backing is equal to +41% and +50%, respectively.[14] The null hypothesis that these two effects are not significantly different from each other cannot be rejected (P>|t|=0.645). Interestingly, investments syndicated by both IVCs and CVCs do not lead to any significant increase in portfolio firms' overall economic performance. This latter result may be due to the small sample size. However, it suggests that the different objectives of IVCs and CVCs may engender substantial agency costs (Chemmanur et al., 2014).

In contrast to the results of Chemmanur et al. (2011) relating to U.S. firms, we do not find any selection effect, as evidenced by the lack of significance of the coefficients of the variables $IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$. The joint test on the three coefficients is F[3; 501]=1.05. One possible reason of this lack of selection effects might be that the attributes through which VCs select target companies in Europe are not apparent from our measure of overall economic performance, i.e. VCs might select target firms according to other characteristics (e.g., quality of firms' management team) that we do not observe. Note however that the few previous studies that assessed the impact of VC

[14] The null hypothesis that IVC, CVC and IVC-CVC syndicated investments have no impact on a portfolio firms' overall economic performance can be tested by performing the following Wald tests: i) $IVC^{POST}_{i,t}$ - $IVC^{PRE}_{i,t}$ = 0; ii) $CVC^{POST}_{i,t}$ - $CVC^{PRE}_{i,t}$ = 0; and iii) $CVCSYND^{POST}_{i,t}$ - $CVCSYND^{PRE}_{i,t}$) = 0, respectively.

investments on the performance of European firms did not find any positive selection effect, independently of the performance measure under consideration (e.g., Bertoni et al., 2011; Bertoni and Tykvova, 2015; Bottazzi et al., 2008; Croce et al., 2013; Grilli and Murtinu, 2014).

In column II, we examine the dynamics of the overall economic performance improvements engendered by the different types of VC investments. As explained in Section 3.2, we distinguish the first two years after the first VC investment (short-term) from the period starting from the third year after VC funding (long-term). The short-term impact of IVC investments on portfolio firms' overall economic performance is positive and significant at 1%, and its magnitude is +26%. The short-term impact of CVC investments is only close to significance, although its estimated magnitude is similar to that of IVC investments. Instead, both the IVC and CVC investments have a statistically significant (at 1%) and economically relevant long-term effect on portfolio firms' overall economic performance: +58% and +67%, respectively.[15] The two long-term effects are not significantly different from each other (P>|t|=0.423). Furthermore, investments syndicated by both IVCs and CVCs are again found to not enhance portfolio firms' overall economic performance either in the short term or in the long term. Our findings on the dynamics of the post-investment effects of IVC investments on portfolio firms' overall economic performance are consistent with the US-based empirical evidence provided by Chemmanur et al. (2011), who estimated a +13% short-term effect and a +25% long-term effect. The discrepancies in the magnitude of the effects may be explained by the fact that the sample used by Chemmanur et al. (2011) also includes medium- and low-tech industries.

[Table 3 about here]

---

[15] The null hypothesis that IVC, CVC and IVC-CVC syndicated investments have no impact on portfolio firms' overall economic performance in the short term can be tested by performing the following Wald tests: i) $IVC^{POST\_SHORT}_{i,t} - IVC^{PRE}_{i,t} = 0$; ii) $CVC^{POST\_SHORT}_{i,t} - CVC^{PRE}_{i,t} = 0$; and iii) $CVCSYND^{POST\_SHORT}_{i,t} - CVCSYND^{PRE}_{i,t} = 0$, respectively. The corresponding tests relating to the long-term impact of VC investments are as follows: i) $IVC^{POST\_LONG}_{i,t} - IVC^{PRE}_{i,t} = 0$; ii) $CVC^{POST\_LONG}_{i,t} - CVC^{PRE}_{i,t} = 0$; and iii) $CVCSYND^{POST\_LONG}_{i,t} - CVCSYND^{PRE}_{i,t} = 0$, respectively.

We next turn to the inspection of the channels through which IVC and CVC investments improve portfolio firms' overall economic performance. We found that the improvements engendered by both types of VC investments are mostly attributable to the *output side*: the estimated long-term effects of IVC and CVC investments on real sales growth are equal to +67% and +58%, respectively (again, the two effects are not significantly different from each other: P>|t|=0.676). However, important differences exist between the effects of these two types of VC investments. IVC investments result in a significant (at 1%) short-term real sales increase, whose estimated magnitude is equal to +36%. The corresponding increases in real payroll expenses and headcount in the short-term are substantially lower (+19% and +21%), and no impact on real fixed assets is observed. As to the CVC investments, the short-term effect on the increase of the real sales value is smaller than that generated by IVC investments (+18%) and is not statistically significant. In the short term, we do not observe any significant effect of CVC investments on real payroll expenses, headcount and real fixed assets. From the third year after the receipt of the first VC investment, we observe a further positive effect on the increase of the real sales value for both IVC- and CVC-backed firms (+31% and +40%, respectively), whereas there is no effect on real payroll expenses, headcount and real fixed assets.

5.2 Alternative identification strategy

As highlighted in Section 3.2, we re-estimated equation (1) using an instrumental variables (IV) methodology to test the robustness of our results.[16] We first estimated a multinomial logit model in a competing-risk scenario. The dependent variable is categorical and assumes three different values according to the identity of the investor that provided the first VC investment: IVC, CVC or a syndicate composed of both IVCs and CVCs. The baseline outcome is represented by the situation of

---

[16] We do not apply this IV procedure to equation (2) because it was impossibile to find sources of exogenous variation (i.e., instruments) that are correlated with the short-term VC variables ($IVC^{POST\_SHORT}_{i,t}$, $CVC^{POST\_SHORT}_{i,t}$ and $CVCSYND^{POST\_SHORT}_{i,t}$) and not with the long-term VC variables ($IVC^{POST\_LONG}_{i,t}$, $CVC^{POST\_LONG}_{i,t}$ and $CVCSYND^{POST\_LONG}_{i,t}$), and vice versa.

no VC financing, i.e., the dependent variable is always equal to zero for all non-VC-backed firms. For VC-backed firms, the dependent variable equals: i) 0 in all years prior to the first VC investment; ii) 1 in the year of the first VC investment if the latter is provided by an IVC investor; iii) 2 in the year of the first VC investment if the latter is provided by a CVC investor and is not syndicated with any IVC investor; iv) 3 in the year of the first VC investment if the latter is provided by an IVC-CVC syndicate. The dependent variable is set to missing in the years after the first VC investment. The likelihood of the outcome j is $p_{it}^{j} = \exp(X_{it}'\beta_j) / [1 + \sum_{j=1}^{3} \exp(X_{it}'\beta_j)]$. Standard errors are clustered at the firm level to take into account the panel nature of our sample. The vector *X* includes the logarithm of the total number of years since firm foundation ($Age_{i,t}$), country dummies, the logarithm of real total assets at time *t-1* ($A_{i,t-1}$), the cash flow to total assets ratio at time *t-1* ($CFTA_{i,t-1}$; source: Orbis), the intangible assets to total assets ratio at time *t-1* ($ITA_{i,t-1}$; source: Orbis), the real sales growth between *t-2* and *t-1* ($Sales\_growth_{i,t-1}$), the overall economic performance at time *t-1* ($OEP_{i,t-1}$), and the patent stock at time *t-1* with yearly depreciation equal to 0.15 ($PatentStock_{i,t-1}$; source: PATSTAT). Moreover, we use the following exclusion restrictions. First, we include the average value of M&As, calculated as the ratio between the total M&A market volume and the total number of deals in the seven countries included in the VICO dataset at the industry level (4-digit NAICS code) at time *t-1* ($Acquisition\_price_{t-1}$; Source: Thomson One Banker). Second, to capture general economic conditions, we included GDP growth between *t-1* and *t* at the country level (*GDP_growth*; source: World Bank). Third, we included two industry-level indicators reflecting the effectiveness of formal (registration of design, trademarks, patents, confidentiality agreements, and copyrights) and informal (secrecy, complexity of design, and lead-time advantage on competitors) mechanisms to protect innovation (*IPR_formal* and *IPR_informal*, respectively). Moreover, we included an industry-level indicator on the importance of universities and higher education institutions as sources of external knowledge (*Science*). These indicators were calculated as the industry-level (3-digit SIC code) average of the values reported by small UK firms (with less than 250 employees) that participated in the Innovation Benchmarking Survey jointly administered by the University of Cambridge and the Massachusetts Institute of Technology in 2004 (Cosh et al., 2006).[17] A χ^2 test rejects the null hypothesis that all exclusion restrictions are jointly null. The value of the statistic is well above the critical value of 10 (Staiger and Stock, 1997): $\chi^2(15)=63.62$. The estimates of the multinomial logit model are reported in Table 4.

[Table 4 about here]

Then, we relied on this first-step estimation to calculate three inverse Mills ratio-type terms to be inserted into equation (1) without "leads" ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$). The results of the estimates are reported in Table 5. Coherent with the results shown in Table 3 (column I), both IVC and CVC investments have a positive impact (significant at 1%) on firms' overall economic performance. The estimated magnitude of these effects is +38% and +45%, respectively. These magnitudes are very similar to those found with our baseline identification strategy (+41% and +50%, respectively). Investments syndicated by both IVC and CVC investors again have a negligible impact on portfolio firms' overall economic performance.

[Table 5 about here]

5.3 Selection on unobservables

As anticipated in Section 3.2, we test the robustness of our results in the light of unknown selection. While in Section 5.2 we control for selection effects due to unobservable variables through an IV methodology, in this Section we use: i) the two tests developed by Chetty et al. (2011) (see also Chetty et al., 2014a,b) to test the correlation between the VC variables and variables omitted from our models, which are potentially correlated with firms' overall economic performance and might

[17] We are deeply indebted to Andy Cosh and Alan Hughes for making us available data on the Innovation Benchmarking Survey.

generate a selection bias in the estimates presented earlier; and ii) the test developed by Altonji et al. (2000) to estimate the maximum amount of selection on unobservables that can exist to still get a significant estimate of our main results.[18]

The idea of Chetty et al. (2011) adapted to our context entails that the estimates shown in Table 3 (column I) and Table 5 consistently measure the impact of the different types of VC investments only if an identifying assumption holds: VC variables are uncorrelated with unobserved components of firms' overall economic performance. As to the latter, we use three sets of country-level variables that have not been used in previous models on the impact of VC investments, but are strong predictors of firm performance: quality of institutions, geography, and religion. First, Rigobon and Rodrik (2005) and Rodrik et al. (2004) have shown that the quality of institutions (typically measured by the rule of law) is a good predictor of firms' economic performance (Acemoglu et al., 2001; Hall and Jones, 1999; North, 1990). Institutions set the structure of incentives faced by economic agents in a country, and such structure impacts their economic performance and growth (Mauro, 1995). As to measures closely related to our dependent variable, Olson et al. (2000) find that "productivity growth is higher in better governed countries" (p. 341). Second, geography is a key determinant of endowment of resources, costs, and diffusion of knowledge and technology (Rodrik et al., 2004: p. 132), and thus it matters in explaining economic performances (Rigobon and Rodrik, 2005; Sachs, 2001). Countries located far from the equator are richer, and thus latitude contributes to explain an important proportion of variance in economic performances. Third, as claimed by Guiso et al. (2003): "There is hardly an aspect of a society's life that is not affected by religion" (p. 226). The authors argue that religion impacts the economic attitudes of economic agents, and find that religious beliefs are associated with "good" economic performances. It is worth noting that there is no reverse causality between firm performance and these three exogenous variables (for more details,

[18] We are grateful to an anonymous reviewer for this suggestion.

see Acemoglu et al., 2005). As to the measures of these three variables omitted from the previous models, we refer to the metrics suggested by La Porta et al. (1999, Appendix B).[19] In order to test the validity of the abovementioned identifying assumption, we first show the correlation between the VC variables ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$, $IVC^{POST}_{i,t}$, $CVC^{POST}_{i,t}$ and $CVCSYND^{POST}_{i,t}$) and firms' predicted overall economic performance based on the variables omitted from our models. More specifically, for each year included in our study, we ran an OLS regression where the dependent variable is $OEP_{i,t}$ and the regressors are the three variables omitted from our models. The predicted overall economic performance for the firm *i* in year *t* is a weighted average of the rule of law, the latitude, and the religious composition of firm's home country. As highlighted in Table 6, there is no correlation between the predicted overall economic performance and the VC variables included in our models in Table 3. In Table 7 (column I) we re-estimate our model (1) but the dependent variable is the predicted overall economic performance. After considering the selection effect, estimates indicate that neither IVC nor CVC investments impact portfolio firms' predicted overall economic performance. The estimated increase in the level of predicted overall economic performance is equal to +0.15% (not statistically significant) and -2.9% (significant at 10%), respectively. When comparing the effects of IVC and CVC investments in Table 7 (column I) and Table 3 (column I), we show that the association between overall economic performance and VC variables does not seem to be driven by sorting on omitted characteristics related to institutions, geography, and religion.

A second test suggested by Chetty et al. (2011) is to include the predicted overall economic performance when estimating our model (1) shown in Table 3 (column I). We report these estimates in Table 7 (column II). After controlling for the predicted overall economic performance, the impact

[19] We are conscious that these variables have some weaknesses, such as their country-level nature, and the fact that they have been built in the year 1999. However, as highlighted by the finance and institution literature (Acemoglu and Johnson, 2005; Beck et al., 2003; Easterly and Levine, 1997; La Porta et al., 1998, 1999), such variables do not change much from year to year.

of IVC-backing on the portfolio firms' overall economic performance remains +41% (significant at 1%), while the impact of CVC-backing changes from +50% to +53% (significant at 1%). These two effects are still not significantly different from each other (P>|t|=0.556). Further, as in Table 3 (column I), investments syndicated by both IVC and CVC investors do not impact portfolio firms' overall economic performance. Still, we do not find any selection effect. Given that the variables about quality of institutions, geography, and religion have strong predictive power for overall economic performance, and at the same time they are not correlated with the VC variables, we derive that the degree of bias in our main models is likely to be small.

[Table 6 about here]

[Table 7 about here]

As to the test developed by Altonji et al. (2000), the idea is to test the sensitivity of our main estimates through *a priori* assumptions about the correlation between the unobserved variables that potentially explain the financing choice of different types of VCs and the dependent variable (OEP). More specifically, we specify three sets of two-equations systems where the dependent variable of the first step is $IVC^{POST}_{i,t}$, $CVC^{POST}_{i,t}$, or $CVCSYND^{POST}_{i,t}$ alternatively; while, the dependent variable of the second step is always the overall economic performance. These three systems of equations are estimated jointly through OLS with standard errors that are robust to heteroskedasticity through the Huber-White method and serial correlation within firms. This way, we closely adhere to the model specification of Altonji et al. (2000). The regressors in the two steps are the same as those included in equation (1): $A_{i,t}$, $Age_{i,t}$, and γ_t. However, these variables are centered through a within transformation, which leads to a FE model specification. When we run these three unconstrained systems of equations, we find a maximum absolute value of correlation of 0.2567 between the error components in the two steps (ρ), and this correlation is negative. Thus, we constrained the values of ρ from -0.3 to +0.1 – similarly to what Altonji et al. (2000) did in their Table 7. As shown in Table 8, our results are not so sensitive to ρ. When we constrain |ρ| to lower values than those found in our unconstrained systems of equations, we see that the impact of IVC and CVC investments is lower but still positive (e.g. at ρ=-0.1, it is equal to +26% and +37%, respectively) and statistically significant until the null value of ρ. While, consistently with our main results in Table 3 (column I) and Table 5, the effect of syndicated investments by both types of VC investor on overall economic performance is not statistically significant. Even when we impose a positive ρ (i.e., a selection bias with an opposite sign than that found in our unconstrained systems of equations), the impact of IVC and CVC investments is still positive (even though not statistically significant; for a similar result, see Altonji et al., 2000).

[Table 8 about here]

5.4 Further robustness checks

We performed four additional robustness checks. First, we inserted in the propensity score matching procedure the overall economic performance among the independent variables. Then, we re-estimated all of the models in Table 3 without "leads" ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$). The results are fully in line with those shown in Table 3 and are available from the authors upon request.

Second, we performed two sensitivity analyses on i) the threshold when distinguishing the short-term impact of VC financing from the long-term impact; and ii) the number of years prior to the first VC investment when defining the "leads" ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$). The results of these two sensitivity analyses are shown in Table 9. In particular, in columns I and II, the "leads" ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$) equal 1 from *t-2* to *t* (column I) and from *t-3* to *t* (column II), with *t* representing the year in which the focal firm received its first VC investment, and 0 otherwise, while $IVC^{POST\_SHORT}_{i,t}$, $IVC^{POST\_LONG}_{i,t}$, $CVC^{POST\_SHORT}_{i,t}$, $CVC^{POST\_LONG}_{i,t}$, $CVCSYND^{POST\_SHORT}_{i,t}$, and $CVCSYND^{POST\_LONG}_{i,t}$ are defined as in Table 3. In columns III, IV and V, the short-term VC variables ($IVC^{POST\_SHORT}_{i,t}$, $CVC^{POST\_SHORT}_{i,t}$ and $CVCSYND^{POST\_SHORT}_{i,t}$) equal 1 from *t+1* to *t+3* (column III), *t+4* (column IV), *t+5* (column V), with *t* representing the year in which the focal firm received its first VC investment, and 0 otherwise. The long-term VC variables

($IVC^{POST\_LONG}_{i,t}$, $CVC^{POST\_LONG}_{i,t}$ and $CVCSYND^{POST\_LONG}_{i,t}$) equal 1 from the fourth year (column III), the fifth year (column IV) or the sixth year after VC funding (column V), and equal 0 otherwise, while the "leads" ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$) are defined as in Table 3. Overall, the results are in line with those presented in Table 3 (column II). The short-term impact of IVC investments on portfolio firms' overall economic performance is always positive and significant at 1%, and its magnitude ranges between +23% (column I) and +40% (column V). The short-term impact of CVC investments is now significant at 10% (columns I and II), 5% (columns III and IV) and 1% (column V), and its estimated magnitude ranges between +33% (column I) and +46% (column V). Both the IVC and CVC investments still have a statistically significant (at 1%) and economically relevant long-term effect on portfolio firms' overall economic performance: the ranges are between +55% (columns I and II) and +65% (column V) for IVC and between +82% (column I) and +88% (column II) for CVC, respectively. The long-term effects of IVC and CVC investments are never significantly different from each other. As in Table 3, investments syndicated by both IVC and CVC investors do not impact portfolio firms' overall economic performance both in the short term and in the long term.

[Table 9 about here]

Third, we re-built our dependent variable under the assumption that the technology exhibits constant returns to scale. More specifically, we estimated a series of industry-specific firm-level Cobb-Douglas production functions identical to those described in Section 3.1, with the only difference that this GMM estimation is constrained: the sum of the coefficients of fixed assets and payroll expenses at time t must be equal to one. This way, if one neglects the methodological problems of the deflation procedure described in Section 3.1, the residuals calculated from every production function collapse to a measure of firm total factor productivity: i.e., an output quantity index divided by an input quantity index.

The results are almost unchanged and are shown in Table 10. In columns I and II, we show the estimates of equations (1) and (2). The results in column I indicate that both IVC and CVC investments have a positive impact (significant at 1%) on the portfolio firms' overall economic performance. The estimated increases are very similar to those exposed in Table 3 and are equal to +36% and +47%, respectively. The null hypothesis that these two effects are not significantly different from each other cannot be rejected (P>|t|=0.648). Also in this case, investments syndicated by both IVC and CVC investors do not impact portfolio firms' overall economic performance. In column II, the short-term impact of IVC investments on portfolio firms' overall economic performance is still positive and significant at 1%, and its magnitude is +20% (very close to that exposed in Table 3). As in our main estimations, the short-term impact of CVC investments is close to significance, and its estimated magnitude is similar to that of IVC investments. In the same way, both IVC and CVC investments have a significant (at 1%) and economically relevant long-term effect on portfolio firms' overall economic performance: +53% and +68%, respectively. The two long-term effects are still not significantly different from each other (P>|t|=0.581). Finally, investments syndicated by both IVC and CVC investors are not effective in improving portfolio firms' overall economic performance both in the short term and in the long term.

[Table 10 about here]

Fourth, we control for VC staging. The theoretical model developed by Wang and Zhou (2004) shows that VC staging plays a key role in controlling agency problems. Accordingly, Tian (2011) shows that VC rounds of financing positively impact IPO propensity, post-IPO operating performance and survival rate, but only if the portfolio firm is far from the VC investor. As measure of VC staging, we use the same metric used by Cumming et al. (2014) and Puri and Zarutskie (2012): the time elapsed since the first VC investment. We insert this variable in our models in Table 3 (column I) and Table 5, and find that its coefficient is positive and statistically significant at 1%: its economic magnitude ranges between 8% and 9%. As to the variables capturing IVC and CVC investments, their impact is still positive and statistically significant, even though with a lower magnitude (+19% and +27%, respectively). Conversely, IVC-CVC syndicated investments again fail to exhibit any positive impact on firms' overall economic performance. Hence, even if part of the effect of the IVC and CVC variables in Table 3 (column I) and Table 5 is due to staging, staging does not drive the results illustrated earlier.[20] The results are available from the authors upon request.

6. Conclusions

In this study, we have compared the impact exerted on portfolio firms' overall economic performance by IVC, CVC and IVC-CVC syndicated investments. We have also examined the dynamics of these effects and the channels through which the improvements in overall economic performance materialize. For this purpose, we have taken advantage of a new panel dataset on European VC-backed and non-VC-backed high-tech entrepreneurial firms. Our results indicate that both IVC and CVC investments improve portfolio firms' overall economic performance, whereas investments by syndicates composed of both types of VC investors do not. The positive effects on portfolio firms' performance are statistically significant and of great economic magnitude. These effects mostly arise from sizeable sales increases. However, important differences emerge between IVC-backed and CVC-backed firms in terms of the dynamics of their sales increases and changes in labor inputs.

First, while the long-term impact of IVC investments on sales value is comparable to the impact of CVC investments, the short-term impact of IVC investments is twice as large as the impact of CVC investments. These results are in line with the view that CVCs are more patient than IVCs. Previous studies have highlighted that it is very important for IVCs to build a reputation as competent investors (Gompers, 1996). IVCs, especially the less established ones, are compelled to find a fast

[20] We are grateful to an anonymous reviewer for this suggestion.

economically viable exit strategy. Accordingly, IVCs are more inclined than CVCs to speed up the time to market, thus leading portfolio firms to the commercialization phase as soon as possible. In fact, sales growth is considered an indicator of business success for entrepreneurial firms (e.g., Weinzimmer et al., 1998) and is positively related to both the likelihood of an IPO (Chemmanur et al., 2010, 2011; Puri and Zarutskie, 2012) and IPO valuation (Brav and Gompers, 1997). Sales growth is also positively related to the likelihood of a trade-sale (Chemmanur et al., 2011; Puri and Zarutskie, 2012), which represents the dominant exit option for VCs in Europe (Bienz and Walz, 2010; Bottazzi and Da Rin, 2002).

Moreover, while IVC investments lead to an increase in labor inputs that are smaller than the sales increase, CVC investments do not have any effect on labor inputs. This latter evidence is in line with the view that CVCs create a symbiotic relationship with their portfolio firms (Gompers and Lerner, 2000; Ivanov and Xie, 2010). Because CVC-backed firms benefit from knowledge transfer and a skilled labor force (e.g., researchers, CVC fund managers) coming from the parent company, they can increase their sales value without any substantial increase in payroll expenses. Conversely, IVC-backed firms rely on their investor's network and the 'certification' effect engendered by VC backing to hire skilled individuals (e.g., professional managers; see, e.g., Colombo and Grilli, 2013; Hellmann and Puri, 2002). In turn, this results in an increase in labor costs. Quite interestingly, this increase is concentrated in the period that immediately follows the first VC investment.

Our results raise some interesting questions for future research. First, we document that the ownership and governance of VCs influences the economic impact of VC investments. However, the literature highlights that there is also a substantial heterogeneity within the two categories of VCs under consideration here (e.g., Da Rin et al. 2013; Dushnitsky and Shapira, 2010). IVCs and CVCs vary in terms of investment experience, organizational structure and human capital of managing partners. These differences are likely to influence the effect of VC financing on portfolio firms' overall economic performance. Furthermore, the relative importance of financial and strategic objectives may be different across the investments made by the same investor. A CVC investor may pursue financial objectives in some investments and strategic objectives in others. As highlighted by MacMillan et al. (2008): "The specific approaches to the strategic mission vary widely, as do the specific forms of CVC structures and processes. Some CVCs are oriented to R&D organizations in the parent company, while others are oriented to the business operating units. Some CVCs are closely affiliated with a particular business within the parent company, while others serve all the businesses. Some CVCs focus on supporting the parent company's existing businesses, while others look to 'white spaces' outside of existing business in order to identify new directions and opportunities". The relatively small sample size prevented us from investigating these interesting issues, which remain high on our research agenda. Second, our study suggests that on average mixed syndicates composed by CVCs and IVCs do not lead to any improvement in economic performance. Besides the small sample size, a possible reason may be the presence of principal-principal agency costs generated by conflicting objectives of different investor types (Colombo et al., 2014; Murtinu, 2015). Future studies should look at the structure and composition of these syndicates – e.g., the number of VCs included in the syndicate, their affiliation, their experience, and their industry-level and country-level specialization – to obtain a better understanding of the source of these agency costs. Finally, the extant literature (e.g., Armour and Cumming, 2006; Black and Gilson, 1998; Jeng and Wells, 2000) argue that institutional factors engender cross-country differences in exit behavior and the risk and return to VC (Cumming and MacIntosh, 2003), intensity of involvement of the investors and holding period of the investment (Manigart et al., 2002), funding sources, stage, industry and geographical focus (Mayer et al., 2005). Following these arguments, future studies should investigate how institutional country-specific factors moderate the performance impact of IVC and CVC investments, and so extend our results to other countries.

References

Acemoglu, D., Johnson, S., 2005. Unbundling institutions. Journal of Political Economy 113,949–995.

Acemoglu, D., Johnson, S., Robinson, J.A., 2001. The colonial origins of comparative development: an empirical investigation. American Economic Review 91, 1369–1401.

Acemoglu, D., Johnson, S., & Robinson, J. (2005). The rise of Europe: Atlantic trade, institutional change, and economic growth. American economic review, 546-579.

Ackerberg, D.A., Caves, K. and Frazer, G. (2006) Structural identification of production functions. Unpublished manuscript.

Altonji, J. G., Elder, T. E., & Taber, C. R. (2000). Selection on observed and unobserved variables: Assessing the effectiveness of Catholic schools (No. w7831). National bureau of economic research.

Amit, R., Brander, J., Zott, C. (1998). "Why do venture capital firms exist? Theory and Canadian evidence". Journal of Business Venturing 13(6), 441-466.

Arellano, M., Bond, S. (1991). "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations". The Review of Economic Studies, 58(2), 277–297.

Arellano, M., Bover., O. (1995). "Another look at instrumental variables estimation of error-component models". Journal of Econometrics 68: 29–51.

Armour, J., Cumming, D., 2006. The legislative road to Silicon Valley. Oxford Economic Papers 58, 596-635.

Beck, T., Demirgüç-Kunt, A., & Levine, R. (2003). Law, endowments, and finance. Journal of Financial Economics, 70(2), 137-181.

Benson D, Ziedonis R. 2009. Corporate venture capital as a window on new technologies: implications for the performance of corporate investors when acquiring startups. Organization Science 20(2): 329–353.

Berger, A.N., and G.F. Udell, 1998. The economics of small business finance: the roles of private equity and debt markets in the financial growth cycles. Journal of Banking and Finance 22, 613-673.

Bertoni, F., Colombo, M.G., Grilli, L., 2011. Venture capital financing and the growth of high-tech start-ups: Disentangling treatment from selection effects. Research Policy, 40(7), 1028-1043.

Bertoni, F., Colombo, M.G., Grilli, L. 2013.Venture capital investor type and the growth mode of new technology-based firms. Small Business Economics, 40(3), 527-552.

Bertoni, F., Colombo, M.G., Quas, A. 2015. The patterns of venture capital investment in Europe. Small Business Economics, forthcoming.

Bertoni, F., Martí, J. (2011). "Financing Entrepreneurial Ventures in Europe: The VICO Dataset" (September 30, 2011). Available at SSRN: http://ssrn.com/abstract=1904297.

Bertoni, F., Tykvová, T. 2015. Does governmental venture capital spur invention and innovation? Evidence from young European biotech companies. Research Policy 44(4), 925-935.

Bienz C., Walz U. 2010. Venture Capital Exit Rights. Journal of Economics & Management Strategy 19(4): 1071–1116.

Black, B.S., and R. J. Gilson. 1998. Venture capital and the structure of capital markets: Banks versus stock markets, Journal of Financial Economics 47, 243-277.

Blundell R., Bond S. (2000). "GMM Estimation with persistent panel data: an application to production functions". *Econometric Reviews* 19(3), 321-340.

Bond, S., Van Reenen, J. (2007). "Microeconometric models of investment and employment". In: Heckman, James J. and Leamer, Edward E., (eds.) Handbook of econometrics. North Holland, London, UK, pp. 4417-4498. ISBN 0444506314

Bottazzi, L., Da Rin, M. (2002). "Venture capital in Europe and the financing of innovative companies". Economic Policy 17(34): 231-269.

Bottazzi, L., Da Rin, M., Hellmann, T.F. (2008). "Who are the active investors? Evidence from venture capital". *Journal of Financial Economics* 89(3), 488-512.

Brander, J., Amit, R., Antweiler, W. (2002). "Venture capital syndication: Improved venture selection versus value-added hypothesis". Journal of Economics and Management Strategy 11(3): 423-452.

Brav, A., Gompers, P.A., 1997. Myth or reality? The long-Run underperformance of initial public offerings: Evidence from venture and nonventure capital-backed companies. Journal of Finance 52, 1791-1821.

Carpenter, R. E., and B. C. Petersen. 2002. Capital market imperfections, high-tech investment, and new equity financing, Economic Journal 112, F54-F72.

Casamatta, C., Haritchabalet, C. (2007). "Experience, screening and syndication in venture capital investments". Journal of Financial Intermediation 16(3): 368-398.

Chahine, S, I. Filatotchev, and R. Hoskisson, 2012. The effects of venture capital syndicate diversity on earnings management and performance of IPOs in the US and UK: An institutional perspective, Journal of Corporate Finance 18, 179-192.

Chemmanur, T.J., He, S., Nandy, D., 2010. The going-public decision and the product market. Review of Financial Studies 23, 1855–908.

Chemmanur, T.J., Krishnan, K., Nandy, D. (2011). "How Does Venture Capital Financing Improve Efficiency in Private Firms? A Look Beneath the Surface”. *The Review of Financial Studies* 24, 4037-4090.

Chemmanur, T.J., Loutskina, E., Tian, X. (2014). Corporate venture capital, value creation, and innovation. Review of Financial Studies, 27(8), 2434-2473.

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2011). The long-term impacts of teachers: Teacher value-added and student outcomes in adulthood (No. w17699). National Bureau of Economic Research.

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2014). Measuring the Impacts of Teachers I: Evaluating Bias in Teacher Value-Added Estimates. The American Economic Review, 104(9), 2593-2632.

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2014b). Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood. The American Economic Review, 104(9), 2633-2679.

Colombo, M.G., Croce, A., Murtinu, S. 2014. Ownership Structure, Horizontal Agency Costs and the Performance of High-Tech Entrepreneurial Firms. Small Business Economics 42(2), 265-282.

Colombo, M.G., D’Adda, D., Pirelli, L.H. 2015. The participation of new technology-based firms in EU funded R&D partnerships: The role of venture capital. Paper presented at the DRUID Society Conference 2014. Available at: http://druid8.sit.aau.dk/druid/acc_papers/6adja4jc4ny6ia26g63ucpoma3fm.pdf.

Colombo, M. G., & Grilli, L. (2013). The Creation of A Middle-Management Level by Entrepreneurial Ventures: Testing Economic Theories of Organizational Design. Journal of Economics & Management Strategy, 22(2), 390-422.

Cosh, A., Hughes, A., Lester, R.K., 2006. UK plc: Just How Innovative Are We? Findings from the Cambridge-MIT Institute International Innovation Benchmarking Project. Massachusetts Institute of Technology, Working Paper Series, MIT-IPC-06-009.

Croce, A., Martí, J., Murtinu, S. 2013. The impact of venture capital on the productivity growth of European entrepreneurial firms: 'Screening' or 'value added' effect?. Journal of Business Venturing 28(4), 489-510.

Cumming, D.J., Fleming, G., Suchard, J. 2005. Venture capitalist value-added activities, fundraising and drawdowns. Journal of Banking & Finance 29(2), 295–331.

Cumming, D.J., Grilli, L., Murtinu, S. 2014. Governmental and independent venture capital investments in Europe: a firm-level performance analysis. Journal of Corporate Finance, in press, doi: 10.1016/j.jcorpfin.2014.10.016.

Cumming, D.J., Macintosh, J. G. 2003. A Cross-Country Comparison of Full and Partial Venture Capital Exits. Journal of Banking and Finance 27, 511-48.

Cumming, D. Siegel and M. Wright, 2007. Private Equity, Leveraged Buyouts and Governance, Journal of Corporate Finance 13(4): 439-460.

Cumming, D.J., Walz, U. (2010). "Private equity returns and disclosure around the world". Journal of International Business Studies 41: 727-754.

Da Gbadji, L.A.G., Gailly, B., Schwienbacher, A. 2014. International Analysis of Venture Capital Programs of Large Corporations and Financial Institutions. Entrepreneurship Theory and Practice, forthcoming: DOI: 10.1111/etap.12105.

Da Rin, M., Hellmann, T.F., Puri, M. (2013). "A Survey of Venture Capital Research". In George Constantinides, Milton Harris, and René Stulz (eds) Handbook of the Economics of Finance, Vol. 2, Amsterdam, North Holland.

De Loecker, J. (2007) Product differentiation, multi-product firms and estimating the impact of trade liberalization on productivity. National Bureau of Economic Research Working Paper Series 13155.

Dehejia, R.H., Wahba, S. (2002). "Propensity score-matching methods for nonexperimental causal studies". *The Review of Economics and Statistics* 84, 151-161.

Denis, D.J. 2004. Entrepreneurial finance : an overview of the issues and evidence, Journal of Corporate Finance 10, 301-326.

Dihiya, S., Ray, K. 2012. Staged investments in entrepreneurial financing, Journal of Corporate Finance 18, 1193-1216.

Dimov, D., Gedajlovic, E. 2010. A property rights perspective on venture capital investment decisions. Journal of Management Studies 47(7), 1248–1271.

Dushnitsky, G. (2012). "Corporate venture capital in the 21st century: an integral part of firms' innovation toolkit". In D. Cummings (Ed.), Oxford Handbook of Venture Capital (pp. 156-210). Oxford, UK: Oxford University Press.

Dushnitsky, G., Lenox, M.J. (2005a). When do firms undertake R&D by investing in new ventures?. Strategic Management Journal 26(10), 947–965.

Dushnitsky, G., Lenox, M.J. (2005b). When do incumbents learn from entrepreneurial ventures? Corporate venture capital and investing firm innovation rates. Research Policy 34, 615-639.

Dushnitsky G, Shapira ZB. 2010. Entrepreneurial finance meets corporate reality: comparing investment practices and performance of corporate and independent venture capitalists. Strategic Management Journal 31(9), 990 – 1017.

Easterly, W., & Levine, R. (1997). Africa's growth tragedy: policies and ethnic divisions. The Quarterly Journal of Economics, 1203-1250.

Fulghieri, P., & Sevilir, M. (2009). Organization and financing of innovation, and the choice between corporate and independent venture capital. Journal of Financial and Quantitative Analysis, 44(06), 1291-1321.

Giot, P., Schwienbacher, A., 2007. IPOs, Trade Sales and Liquidations: Modelling Venture Capital Exits Using Survival Analysis. Journal of Banking & Finance, 31 (3), 679-702.

Gompers, P., 1995. Optimal investment, monitoring, and the staging of venture capital. Journal of Finance 50, 1461-1489.

Gompers, P.A., 1996. Grandstanding in the venture capital industry. Journal of Financial Economics 42, 133-156.

Gompers, P.A. 2002. Corporations and the financing of innovation: the corporate venturing experience. Federal Reserve Bank of Atlanta Economic Review Fourth Quarter, 1-16.

Gompers, P., Kovner, A., Lerner J. 2009. Specialization and Success: Evidence from Venture Capital. Journal of Economics & Management Strategy 18(3): 817–844.

Gompers, P., Lerner, J. (2000). "The Determinants of Corporate Venture Capital Success". In R. Morck, Ed., Concentrated Corporate Ownership, Chicago, IL, University of Chicago Press.

Gompers, P., J. Lerner, (2001). "The venture capital revolution", Journal of Economic Perspectives 15, 145–168.

Gompers, P.A. and J. Lerner, 2004. The Venture Capital Cycle. 2nd Ed. Cambridge: MIT Press.

Gorman, M., Sahlman, W.A., 1989. What do venture capitalist do?. Journal of Business Venturing, 4, 231-248.

Grilli, L., Murtinu, S. 2014. Government, venture capital and the growth of European high-tech entrepreneurial firms. Research Policy 43(9), 1523-1543.

Grilli, L., Murtinu, S. 2015. New technology-based firms in Europe: market penetration, public venture capital, and timing of investment. Industrial and Corporate Change, 24(5), 1109-1148.

Guiso, L., Sapienza, P., & Zingales, L. (2003). People's opium? Religion and economic attitudes. Journal of monetary economics, 50(1), 225-282.

Hall, R. E., & Jones, C. I. (1999). Why Do Some Countries Produce So Much More Output Per Worker Than Others?. The Quarterly Journal of Economics, 114(1), 83-116.

Hellmann, T., 2002. A theory of strategic venture investing. Journal of Financial Economics 64, 285-314.

Hellmann, T., Puri, M. (2000). "The interaction between product market and financing strategy: the role of venture capital". The Review of Financial Studies 13(4): 959-984.

Hellmann, T., Puri, M., (2002). Venture capital and the professionalization of start-up firms: empirical evidence. Journal of Finance 57, 169 – 197.

Hochberg, Y.V., Ljungqvist A., Lu Y. 2007. Whom You Know Matters: Venture Capital Networks and Investment Performance. Journal of Finance 62(1): 251–301.

Hsu D.H., 2004. What do entrepreneurs pay for venture capital affiliation? Journal of Finance 59, 1805–1844.

Hsu, D.H., (2006). "Venture Capitalists and Cooperative Start-up Commercialization Strategy". Management Science 52: 204-219.

Ivanov, V.I., Xie, F. (2010). "Do Corporate Venture Capitalists Add Value to Startup Firms? Evidence from IPOs and Acquisitions of VC-Backed Companies". *Financial Management* 39, 129-152.

Jeng, L.A., Wells, P.C., 2000. The determinants of venture capital funding: Evidence across countries. Journal of Corporate Finance 6, 241-289.

Kaplan S.N., Strömberg P. (2003). “Financial Contracting Theory Meets the Real World: An Empirical Analysis of Venture Capital Contracts”. Review of Economic Studies 70(2): 281.

Kaplan S.N., Strömberg P. (2004). Characteristics, contracts and actions: evidence from venture capital analyses. Journal of Finance 59(5): 2177-2210.

Katayama, H., Lu, S. and Tybout, J.R. (2009) Firm-level productivity studies: illusions and a solution. International Journal of Industrial Organization 27: 403–413.

Katila, R., Rosenberger, J., Eisenhardt, K. (2008). “Swimming with sharks: Technology ventures defense mechanisms and corporate relationships”. Administrative Science Quarterly 53: 295–332.

Kortum, S., Lerner, J. (2000). "Assessing the contribution of venture capital to innovation". *Rand Journal of Economics* 31, 674-692.

Kovner, A., Lerner, J. 2015. Doing Well by Doing Good? Community Development Venture Capital. Journal of Economics & Management Strategy 24(3), 643-663.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R., (1998), "Law and finance," Journal of Political Economy, 106, 1115–1155.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (1999). The quality of government. Journal of Law, Economics, and organization, 15(1), 222-279.

Lerner, J. (1994). “The syndication of venture capital investments”. Financial Management 23(3): 16-27.

Lerner J. (1995). “Venture capitalists and the oversight of private firms”. Journal of Finance, 50: 301-318.

Lindsey, L. (2008). “Blurring Firm Boundaries: The Role of Venture Capital in Strategic Alliances”. The Journal of Finance, 63: 1137–1168.

MacMillan I., Roberts E., Livada V., Wang A. 2008. Corporate Venture Capital (CVC) Seeking Innovation and Strategic Growth. Recent patterns in CVC mission, structure, and investment. National Institute of Standards and Technology, June 2008.

Mairesse, J., Hall B.H. (1996). “Estimating the Productivity of Research and Development in French and US Manufacturing Firms: an Exploration of Simultaneity Issues with GMM Methods”, in Wagner, K. and B. Van Ark (eds.), International Productivity Differences and Their Explanations, Elsevier Science, 285-315.

Manigart, S., De Waele, K., Wright, M., Robbie, K., Desbrières, P., Sapienza, H.J., Beekman, A. 2002. Determinants of required return in venture capital investments: a five-country study. Journal of Business Venturing 17, 291–312.

Mauro, P. (1995). Corruption and growth. The quarterly journal of economics, 681-712.

Mayer, C., Schoors, K., Yafeh, Y., 2005. Sources of funds and investment activities of venture capital funds: evidence from Germany, Israel, Japan and the United Kingdom. Journal of Corporate Finance 11, 586-608.

Megginson, W.L., Weiss, K.A., 1991. Venture Capitalist Certification in Initial Public Offerings. Journal of Finance, 46(3), 879-903.

Murtinu, S. 2015. Debt Maturity, Ownership Concentration, and Firm Efficiency. Economics Bulletin 35(4), A262.

North, D. C. (1990). Institutions, institutional change and economic performance. Cambridge university press.

Olson Jr, M., Sarna, N., & Swamy, A. V. (2000). Governance and growth: A simple hypothesis explaining cross-country differences in productivity growth. Public Choice, 102(3-4), 341-364.

Park, H.D., and Steensma, H.K., 2012. When does corporate venture capital add value?. Strategic Management Journal 33, 1-22.

Park, H.D., and Steensma, H. K., 2013. The selection and nurturing effects of corporate investors on new venture innovativeness. Strategic Entrepreneurship Journal 7, 311-330.

Puri, M., Zarutskie, R. (2012). "On the lifecycle dynamics of venture-capital and non-venture-capital-financed firms". *The Journal of Finance* 67(6), 2247-2293.

Rigobon, R., & Rodrik, D. (2005). Rule of law, democracy, openness, and income. Economics of transition, 13(3), 533-564.

Riyanto, Y. E., & Schwienbacher, A. (2006). The strategic use of corporate venture financing for securing demand. Journal of Banking & Finance, 30(10), 2809-2833.

Rodrik, D., Subramanian, A., & Trebbi, F. (2004). Institutions rule: the primacy of institutions over geography and integration in economic development. Journal of economic growth, 9(2), 131-165.

Sachs, J. D. (2001). Tropical underdevelopment (No. w8119). National Bureau of Economic Research.

Sahlman W.A. (1990). "The structure and governance of venture-capital organizations". *The Journal of Financial Economics*, 27(2), 473-521.

Semykina, A., Wooldridge, J.M., 2010. Estimating panel data models in the presence of endogeneity and selection. Journal of Econometrics 157, 375-380.

Solow, R.M. (1957) Technical change and the aggregate production function. Review of Economics and Statistics 39: 312–320.

Staiger, D., Stock, J.H. (1997). "Instrumental variables regression with weak instruments". Econometrica 65, 557-586.

Stiglitz, J.E. (1989). "Markets, Market Failures, and Development". The American Economic Review 79(2), 197-203.

Tian, X. 2011. The Causes and Consequences of Venture Capital Stage Financing. Journal of Financial Economics 101(1), 132-159.

Tian, X. 2012. The Role of venture capital syndication in value creation for entrepreneurial firms. Review of Finance 16, 245-283.

Van Beveren, I. 2012. Total factor productivity estimation: a practical review. Journal of Economic Surveys 26(1), 98–128.

Van Biesebroeck, J., 2007. Robustness of productivity estimates. Journal of Industrial Economics, 55, 529-569.

Wadhwa, A., Phelps, C., Kotha, S. 2015. Corporate venture capital portfolios and firm innovation. Journal of Business Venturing, in press.

Wang, S., and H. Zhou, 2004. Staged financing in venture capital: Moral hazard and risks, Journal of Corporate Finance 10, 131–155.

Weinzimmer, L. G., Nystrom, P. C., Freeman, S. J. (1998). "Measuring organizational growth: Issues, consequences and guidelines". Journal of Management 24(2): 235–262.

Windmeijer, F., 2005. A finite sample correction for the variance of linear efficient two-step GMM estimators. Journal of Econometrics 126, 25-51.

Wooldridge, J.M. (2009) On estimating firm-level production functions using proxy variables to control for unobservables. Economics Letters 104(3): 112–114.

Wright M., Lockett A., (2003). “The Structure and Management of Alliances: Syndication in the Venture Capital Industry”. Journal of Management Studies 40(8): 2073-2102.

Tables

Table 1. Descriptive statistics (period 1992-2010)

Panel A	**Matched non-VC-backed firms**	**IVC-backed firms**		**CVC-backed firms**		**CVCSYND-backed firms**	
	I	II	III	IV	V	VI	VII
		Pre-investment	Post-investment	Pre-investment	Post-investment	Pre-investment	Post-investment
	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Sales value (k€)	7,162.1 (34,441.9)	2,066.8 (4,900.6)	9,481.6 (35,245.3)	1,432.1 (1,732.1)	5,969.3 (9,756.5)	808.7 (1,005.9)	5,184.5 (9,555.4)
Fixed assets (k€)	5,019.1 (114,328.2)	555.2 (1,217.1)	2,958.8 (12,699.0)	581.9 (525.1)	1,975.3 (4,902.2)	784.7 (1,496.3)	3,011.9 (10,929.4)
Payroll expenses (k€)	2,233.3 (7,773.5)	919.7 (1,963.4)	2,793.1 (4,554.0)	652.7 (612.4)	2,401.1 (3,599.1)	425.5 (313.5)	2,658.0 (3,072.8)
Headcount	49.5 (151.1)	25.6 (52.7)	52.7 (82.0)	14.8 (11.0)	45.0 (64.4)	11.1 (7.5)	40.7 (47.3)
Total assets (k€)	10,373.7 (139,511.7)	2,126.4 (3,883.8)	19,662.9 (135,898.4)	2,247.5 (3,144.1)	9,085.7 (18,087.8)	1,906.8 (2,021.6)	16,461.1 (30,568.7)

Panel B	Matched non-VC-backed firms	IVC-backed firms		CVC-backed firms		CVCSYND-backed firms	
	I	II	III	IV	V	VI	VII
		Pre-investment	Post-investment	Pre-investment	Post-investment	Pre-investment	Post-investment
	Median	Median	Median	Median	Median	Median	Median
Sales value (k€)	1,122.2	478	1,978	1,060.5	2,408	222.5	1,939.5
Fixed assets (k€)	112.9	161.1	493.7	440.1	577.8	203.8	597.1
Payroll expenses (k€)	456	341	1,325	442	1,297	373.5	1,871
Headcount	14	11	28	13	26	7	23
Total assets (k€)	991	854	3,591	909	3,133	1,576.5	4,334.5

Legend. In Panel A, in columns I, II, III, IV, V, VI and VII, the mean value of the focal variable related to the matched non-VC-backed firms, IVC-backed firms in the years before the first VC investment, IVC-backed firms in the years after the first VC investment, CVC-backed firms in the years before the first VC investment, CVC-backed firms in the years after the first VC investment, CVCSYND-backed firms in the years before the first VC investment, and CVCSYND-backed firms in the years after the first VC investment, respectively. Standard deviations in round brackets. In Panel B, in columns I, II, III, IV, V, VI and VII, the median value of the focal variable related to the matched non-VC-backed firms, IVC-backed firms in the years before the first VC investment, IVC-backed firms in the years after the first VC investment, CVC-backed firms in the years before the first VC investment, CVC-backed firms in the years after the first VC investment, CVCSYND-backed firms in the years before the first VC investment, and CVCSYND-backed firms in the years after the first VC investment, respectively.

Table 2. Univariate analysis on VC-backed firms' overall economic performance before and after obtaining VC (period 1992-2010)

	Pre-investment	Post-investment	Difference
	I	II	III
IVC-backed firms	2.5725	3.2971	0.7246***
	(0.1145)	(0.0496)	(0.1248)
CVC-backed firms	2.8164	3.9413	1.1249***
	(0.3201)	(0.1467)	(0.3521)
CVCSYND-backed firms	2.2398	2.5594	0.3196
	(0.4230)	(0.1700)	(0.4559)

Legend. In columns I and II, we report the mean and standard error of the overall economic performance of portfolio firms in the years before and after the first VC investment, respectively. In column III, we report the Wald test on the difference between the mean overall economic performance in the years before the first VC investment and the mean overall economic performance in the years after the first VC investment. * p-value<10%, ** p-value<5%, *** p-value<1%.

Table 3. Estimates of the impact of IVC, CVC and IVC-CVC syndicated investments on European high-tech entrepreneurial firms' overall economic performance and its components (period 1992-2010)

	OEP	OEP	Sales	Fixed assets	Payroll expenses	Headcount
	I	II	III	IV	V	VI
$IVC^{PRE}_{i,t}$	-0.0710 (0.1407)	-0.0474 (0.1411)	0.1088 (0.1396)	0.1082 (0.1244)	0.2860*** (0.0846)	0.1553** (0.0677)
$IVC^{POST}_{i,t}$	0.3411** (0.1426)	-	-	-	-	-
$IVC^{POST\_SHORT}_{i,t}$	-	0.2135 (0.1403)	0.4710*** (0.1401)	0.1767 (0.1406)	0.4779*** (0.0922)	0.3607*** (0.0828)
$IVC^{POST\_LONG}_{i,t}$	-	0.5292*** (0.1578)	0.7757*** (0.1604)	0.1021 (0.1666)	0.4761*** (0.1114)	0.3237*** (0.0991)
$CVC^{PRE}_{i,t}$	0.2820 (0.4202)	0.3447 (0.4156)	0.4505 (0.4122)	0.0306 (0.3365)	0.4650 (0.3349)	0.1897 (0.2119)
$CVC^{POST}_{i,t}$	0.7865* (0.4388)	-	-	-	-	-
$CVC^{POST\_SHORT}_{i,t}$	-	0.6208 (0.4437)	0.6344 (0.4295)	-0.0344 (0.4711)	0.3377 (0.3596)	0.2244 (0.2341)
$CVC^{POST\_LONG}_{i,t}$	-	1.1092** (0.4461)	1.0266** (0.4324)	-0.0245 (0.4570)	0.3484 (0.4047)	0.2944 (0.2384)
$CVCSYND^{PRE}_{i,t}$	-1.0908 (0.7001)	-1.0675 (0.6911)	-1.0765 (0.7306)	-0.1791 (0.3941)	0.1300 (0.1920)	-0.2424** (0.1206)
$CVCSYND^{POST}_{i,t}$	-1.0761 (0.6763)	-	-	-	-	-
$CVCSYND^{POST\_SHORT}_{i,t}$	-	-1.0646 (0.6630)	-0.8640 (0.7531)	-0.1191 (0.4296)	0.4442* (0.2307)	0.1803 (0.1213)
$CVCSYND^{POST\_LONG}_{i,t}$	-	-0.9685 (0.7154)	-0.8068 (0.8074)	-0.1774 (0.4455)	0.3574 (0.2574)	0.0839 (0.1304)
$Age_{i,t}$	0.8181*** (0.1426)	0.8092*** (0.1429)	0.9863*** (0.1595)	0.2212 (0.1880)	0.4833*** (0.1177)	0.3924*** (0.1004)
$A_{i,t}$	0.1679*** (0.0393)	0.1684*** (0.0388)	0.5641*** (0.0503)	0.9593***(0.0699)	0.5997*** (0.0414)	0.3698*** (0.0322)
γ_t	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	4459	4459	4459	4459	4459	3889
Groups	502	502	502	502	502	497
R^2	0.0722	0.0732	0.4110	0.5755	0.6403	0.5929

Legend. The dependent variables are the overall economic performance (columns I and II), the logarithm of sales value (column III), the logarithm of fixed assets (column IV), the logarithm of payroll expenses (column V) and the logarithm of headcount (column VI). Time dummies are included in the estimates (coefficients are omitted in the table). Estimates are derived from FE regressions with standard errors robust to heteroskedasticity through the Huber-White method and serial correlation within firms. All regressions are estimated with an intercept term. Standard errors in round brackets. Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * p < .10; ** p < .05; *** p < .01.

Table 4. Alternative identification strategy: first-step instrumental variables (IV) estimates (period 1992-2010)

	IVC	CVC	CVCSYND
	I	II	III
$Age_{i, t}$	-0.2268*** (0.0277)	-0.2843*** (0.0889)	-0.4183*** (0.1386)
$A_{i, t-1}$	0.2206*** (0.0448)	0.1863* (0.1123)	0.0285 (0.1739)
$CFTA_{i, t-1}$	0.5690** (0.2831)	-0.0147 (1.3041)	-2.8588*** (1.0578)
$ITA_{i, t-1}$	0.2871 (0.5557)	1.4796* (0.7875)	1.3286 (2.3163)
$Sales\_growth_{i, t-1}$	0.2675*** (0.0700)	0.3136* (0.1636)	-0.4579 (0.3204)
$OEP_{i, t-1}$	-0.3732*** (0.0575)	-0.3704*** (0.1211)	-0.1339 (0.3288)
$PatentStock_{i, t-1}$	0.0086 (0.0061)	0.0103 (0.0096)	0.0324** (0.0126)
$Acquisition\_price_{t-1}$	0.0365*** (0.0095)	0.0341*** (0.0097)	0.0182 (0.0144)
GDP_growth	0.5543*** (0.1101)	-0.0380 (0.2067)	0.6586* (0.3678)
IPR_formal	-0.6194 (2.2524)	6.5672** (3.0200)	-0.0343 (4.0942)
IPR_informal	5.8229*** (2.0019)	3.5875 (4.0361)	-2.3686 (5.4677)
Science	-0.7040 (1.3088)	-0.8318 (3.8377)	1.8855 (3.9977)
Country dummies	Yes	Yes	Yes
Obs.	29091	29091	29091
Groups	4015	4015	4015
Pseudo R^2	0.1602	0.1602	0.1602
Log pseudolikelihood	-821.76676	-821.76676	-821.76676

Legend: estimates are derived from multinomial logit regressions (in a competing risk scenario) with standard errors robust to heteroskedasticity through the Huber-White method and serial correlation within portfolio firms. In column I, results related to the likelihood of IVC-backing; in column II, results related to the likelihood of CVC-backing; in column III, results related to the likelihood of CVCSYND-backing. Country dummies are included in the estimates (coefficients are omitted in the table). All regressions are estimated with an intercept term. Standard errors in round brackets. Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * $p < .10$; ** $p < .05$; *** $p < .01$.

Table 5. Alternative identification strategy: second-step instrumental variables (IV) estimates (period 1992-2010)

	OEP
$A_{i, t}$	0.1871*** (0.0378)
$IVC^{POST}_{i, t}$	0.3772*** (0.0805)
$CVC^{POST}_{i, t}$	0.4496*** (0.1698)
$CVCSYND^{POST}_{i, t}$	0.0247 (0.2347)
$Age_{i, t}$	0.7675*** (0.1341)
γ_t	Yes
IMR	Yes
Obs.	3617
Groups	502
R^2	0.1377

Legend. The dependent variable is the overall economic performance. Time dummies are included in the estimates (coefficients are omitted in the table). Estimates are derived from FE regressions with standard errors robust to heteroskedasticity through the Huber-White method and serial correlation within firms. The regression is estimated with an intercept term. Standard errors in round brackets. Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * p < .10; ** p < .05; *** p < .01.

Table 6. First test proposed by Chetty et al. (2011) (period 1992-2010)

	Predicted OEP
$IVC^{PRE}_{i,t}$	-0.0002
$CVC^{PRE}_{i,t}$	-0.0056
$CVCSYND^{PRE}_{i,t}$	0.0008
$IVC^{POST}_{i,t}$	0.0024
$CVC^{POST}_{i,t}$	-0.0016
$CVCSYND^{POST}_{i,t}$	-0.0038

Legend. *Predicted OEP* is the predicted value of a series of yearly OLS regressions where the dependent variable is the overall economic performance and the regressors are the country-level rule of law, latitude, and religious composition (source: La Porta et al., 1999, Appendix B). We report the pairwise correlations between *Predicted OEP* and the VC variables included in our main model (Table 3, column I). Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * $p < .10$; ** $p < .05$; *** $p < .01$.

Table 7. Second test proposed by Chetty et al. (2011) (period 1992-2010)

	Predicted OEP	OEP
	I	II
$IVC^{PRE}_{i,t}$	0.0071 (0.0130)	-0.0769 (0.1392)
$IVC^{POST}_{i,t}$	0.0086 (0.0164)	0.3340** (0.1402)
$CVC^{PRE}_{i,t}$	0.0512** (0.0208)	0.2397 (0.4214)
$CVC^{POST}_{i,t}$	0.0221 (0.0294)	0.7683* (0.4393)
$CVCSYND^{PRE}_{i,t}$	0.1024* (0.0531)	-1.1754* (0.6697)
$CVCSYND^{POST}_{i,t}$	0.1189** (0.0541)	-1.1744* (0.6416)
$Age_{i,t}$	0.0091 (0.0152)	0.8106*** (0.1426)
$A_{i,t}$	0.0019 (0.0033)	0.1664*** (0.0396)
Predicted OEP	-	0.8261*** (0.2344)
γ_t	Yes	Yes
Obs.	4459	4459
Groups	502	502
R^2	0.0612	0.1185

Legend. The dependent variables are the predicted overall economic performance (column I), and the overall economic performance (column II). Time dummies are included in the estimates (coefficients are omitted in the table). Estimates are derived from FE regressions with standard errors robust to heteroskedasticity through the Huber-White method and serial correlation within firms. All regressions are estimated with an intercept term. Standard errors in round brackets. Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * p < .10; ** p < .05; *** p < .01.

Table 8. Test proposed by Altonji et al. (2000) (period 1992-2010)

	OEP	OEP	OEP	OEP	OEP
	I	II	III	IV	V
$IVC^{POST}_{i, t}$	0.5285*** (0.0345)	0.3982*** (0.0319)	0.2665*** (0.0303)	0.1341*** (0.0298)	0.0017 (0.0307)
$CVC^{POST}_{i, t}$	0.7165*** (0.0708)	0.5480*** (0.0675)	0.3746*** (0.0654)	0.1985*** (0.0646)	0.0225 (0.0653)
$CVCSYND^{POST}_{i, t}$	0.4947*** (0.1012)	0.3199*** (0.0978)	0.1406 (0.0956)	-0.0413 (0.0947)	-0.2228** (0.0953)
Obs.	4459	4459	4459	4459	4459
Groups	502	502	502	502	502
R^2					
ρ	-0.3	-0.2	-0.1	0	+0.1

Legend. The dependent variable is the overall economic performance (columns I-V). Time dummies, $A_{i,t}$, and $Age_{i,t}$ are included in the estimates (coefficients are omitted in the table), and centered through a within transformation. Estimates are derived from three sets of two-equations systems jointly estimated through OLS with standard errors that are robust to heteroskedasticity through the Huber-White method and serial correlation within firms. The dependent variable of the first step is $IVC^{POST}_{i,t}$, $CVC^{POST}_{i,t}$, and $CVCSYND^{POST}_{i,t}$ alternatively. The dependent variable of the second step is the overall economic performance. ρ is the correlation between the error components in the two steps of the procedure. All regressions are estimated with an intercept term. Standard errors in round brackets. Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * p < .10; ** p < .05; *** p < .01.

Table 9. Estimates of the impact of IVC, CVC and IVC-CVC syndicated investments on European high-tech entrepreneurial firms' overall economic performance: different thresholds (period 1992-2010)

	OEP	OEP	OEP	OEP	OEP
	I	II	III	IV	V
$IVC^{PRE}_{i,t}$	0.1115 (0.1565)	0.1675 (0.1926)	-0.0484 (0.1409)	-0.0507 (0.1404)	-0.0534 (0.1405)
$IVC^{POST\_SHORT}_{i,t}$	0.3398** (0.1625)	0.4000** (0.2009)	0.2780* (0.1424)	0.3283** (0.1436)	0.3418** (0.1429)
$IVC^{POST\_LONG}_{i,t}$	0.6596*** (0.1813)	0.7189*** (0.2198)	0.5820*** (0.1596)	0.5751*** (0.1617)	0.5926*** (0.1682)
$CVC^{PRE}_{i,t}$	0.3264 (0.4140)	-0.0731 (0.3553)	0.3514 (0.4148)	0.3396 (0.4186)	0.3241 (0.4197)
$CVC^{POST\_SHORT}_{i,t}$	0.6576 (0.4819)	0.3337 (0.3995)	0.7146 (0.4421)	0.7594* (0.4455)	0.7839* (0.4450)
$CVC^{POST\_LONG}_{i,t}$	1.1461** (0.4818)	0.8094** (0.4043)	1.1860*** (0.4503)	1.2030*** (0.4592)	1.1830** (0.4637)
$CVCSYND^{PRE}_{i,t}$	-1.2361 (1.0091)	-0.9884 (1.1533)	-1.0660 (0.6891)	-1.0627 (0.6883)	-1.0588 (0.6918)
$CVCSYND^{POST\_SHORT}_{i,t}$	-1.3015 (0.9972)	-1.1766 (1.1982)	-1.0911* (0.6566)	-1.1161* (0.6601)	-1.0877 (0.6653)
$CVCSYND^{POST\_LONG}_{i,t}$	-1.1948 (1.0254)	-1.0644 (1.2163)	-0.8824 (0.7129)	-0.7305 (0.6757)	-0.6435 (0.6735)
$Age_{i,t}$	0.8174*** (0.1413)	0.8191*** (0.1404)	0.8296*** (0.1428)	0.8444*** (0.1423)	0.8531*** (0.1416)
$A_{i,t}$	0.1611*** (0.0387)	0.1632*** (0.0389)	0.1690*** (0.0387)	0.1679*** (0.0387)	0.1682*** (0.0389)
γ_t	Yes	Yes	Yes	Yes	Yes
Obs.	4459	4459	4459	4459	4459
Groups	502	502	502	502	502
R^2	0.0647	0.0603	0.0729	0.0727	0.0725

Legend. The dependent variable is the overall economic performance. In columns I and II, the "leads" ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$) equal 1 from *t-2* to *t* (column I) and from *t-3* to *t* (column II), with *t* representing the year in which the focal firm received its first VC investment, and 0 otherwise, while $IVC^{POST\_SHORT}_{i,t}$, $IVC^{POST\_LONG}_{i,t}$, $CVC^{POST\_SHORT}_{i,t}$, $CVC^{POST\_LONG}_{i,t}$, $CVCSYND^{POST\_SHORT}_{i,t}$, and $CVCSYND^{POST\_LONG}_{i,t}$ are defined as in Table 3. In columns III, IV and V, the short-term VC variables ($IVC^{POST\_SHORT}_{i,t}$, $CVC^{POST\_SHORT}_{i,t}$ and $CVCSYND^{POST\_SHORT}_{i,t}$) equal 1 from *t+1* to *t+3* (column III), *t+4* (column IV), *t+5* (column V), with *t* representing the year in which the focal firm received its first VC investment, and 0 otherwise. The long-term VC variables ($IVC^{POST\_LONG}_{i,t}$, $CVC^{POST\_LONG}_{i,t}$ and $CVCSYND^{POST\_LONG}_{i,t}$) equal 1 from the fourth year (column III), the fifth year (column IV) or the sixth year after VC funding (column V), and equal 0 otherwise, while the "leads" ($IVC^{PRE}_{i,t}$, $CVC^{PRE}_{i,t}$ and $CVCSYND^{PRE}_{i,t}$) are defined as in Table 3. Time dummies are included in the estimates (coefficients are omitted in the table). Estimates are derived from FE regressions with standard errors robust to heteroskedasticity through the Huber-White method and serial correlation within firms. All regressions are estimated with an intercept term. Standard errors in round brackets. Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * $p < .10$; ** $p < .05$; *** $p < .01$.

Table 10. Estimates of the impact of IVC, CVC and IVC-CVC syndicated investments on European high-tech entrepreneurial firms' overall economic performance: constant returns to scale (period 1992-2010)

	OEP	OEP
	I	II
$IVC^{PRE}_{i,t}$	-0.1574 (0.1458)	-0.1334 (0.1461)
$IVC^{POST}_{i,t}$	0.2045 (0.1467)	-
$IVC^{POST\_SHORT}_{i,t}$	-	0.0689 (0.1451)
$IVC^{POST\_LONG}_{i,t}$	-	0.3989** (0.1619)
$CVC^{PRE}_{i,t}$	0.0467 (0.2867)	0.1016 (0.2825)
$CVC^{POST}_{i,t}$	0.5135* (0.3034)	-
$CVC^{POST\_SHORT}_{i,t}$	-	0.4040 (0.3158)
$CVC^{POST\_LONG}_{i,t}$	-	0.7814** (0.3208)
$CVCSYND^{PRE}_{i,t}$	-1.1234* (0.6700)	-1.0983* (0.6596)
$CVCSYND^{POST}_{i,t}$	-1.1263* (0.6124)	-
$CVCSYND^{POST\_SHORT}_{i,t}$	-	-1.1490* (0.5973)
$CVCSYND^{POST\_LONG}_{i,t}$	-	-0.9901 (0.6515)
$Age_{i,t}$	0.5927*** (0.1402)	0.5856*** (0.1406)
$A_{i,t}$	-0.1340*** (0.0384)	-0.1328*** (0.0383)
γ_t	Yes	Yes
Obs.	4459	4459
Groups	502	502
R^2	0.0736	0.0711

Legend. The dependent variable is the overall economic performance. Time dummies are included in the estimates (coefficients are omitted in the table). Estimates are derived from FE regressions with standard errors robust to heteroskedasticity through the Huber-White method and serial correlation within firms. All regressions are estimated with an intercept term. Standard errors in round brackets. Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * p < .10; ** p < .05; *** p < .01.

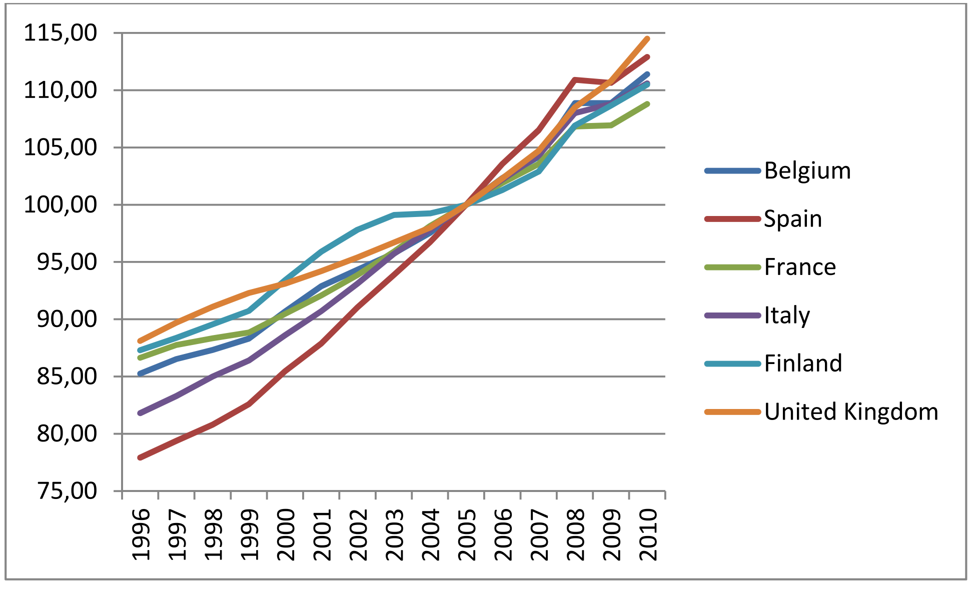
Appendix

Table A.1. TFP estimates (period 1992-2010)

	Sales	Sales	Sales	Sales	Sales	Sales	Sales
	I	II	III	IV	V	VI	VII
$L_{i,t}$	0.3380*** (0.0630)	0.4723*** (0.0881)	0.3577*** (0.0510)	0.5742*** (0.0854)	0.2605** (0.1016)	0.5751*** (0.1000)	0.4635*** (0.1158)
$L_{i,t-1}$	-0.1511*** (0.0493)	-0.2496*** (0.0826)	-0.1411*** (0.0399)	-0.1098 (0.0687)	-0.0274 (0.0866)	-0.0058 (0.0860)	-0.0826 (0.1333)
$K_{i,t}$	0.0695*** (0.0263)	0.1593*** (0.0570)	0.1309*** (0.0327)	0.1711** (0.0747)	0.0111 (0.0695)	-0.0505 (0.0403)	0.0375 (0.0559)
$K_{i,t-1}$	0.0077 (0.0297)	0.0523 (0.0573)	-0.0604** (0.0303)	-0.0990 (0.0890)	-0.0382 (0.0792)	0.1544*** (0.0544)	-0.0109 (0.0450)
$Sales_{i,t-1}$	0.6129*** (0.0475)	0.4159*** (0.0992)	0.5702*** (0.0446)	0.3782*** (0.0883)	0.4754*** (0.0714)	0.2030** (0.0850)	0.4038*** (0.0535)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
γ_t	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	4882	1836	17207	8049	3296	2766	2553
Groups	734	293	2621	1040	482	346	376
Hansen	320.92 [411]	225.49 [416]	480.59 [504]	476.36 [519]	294.59 [462]	303.78 [456]	213.02 [337]
γ^2 ($L_{i,t} + K_{i,t} = 1$)	81.50*** [1]	14.04*** [1]	77.97*** [1]	4.17** [1]	37.25*** [1]	21.59*** [1]	12.02*** [1]

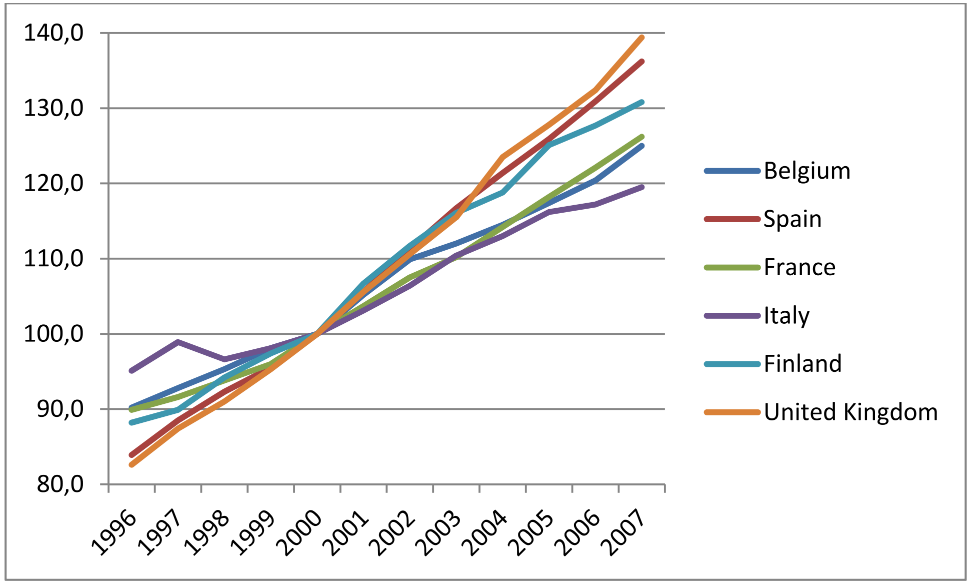
Legend. Each column represents an industry-specific firm-level Cobb-Douglas production function. The industries are: internet (column I), telecommunication services (column II), software (column III), ICT manufacturing (column IV), biotechnology and pharmaceuticals (column V), other high-tech manufacturing (column VI), and other high-tech services (column VII). The dependent variable is the logarithm of sales value. $L_{i,t}$ is the logarithm of payroll expenses at time *t*. $L_{i,t-1}$ is the logarithm of payroll expenses at time *t-1*. $K_{i,t}$ is the logarithm of fixed assets at time *t*. $K_{i,t-1}$ is the logarithm of fixed assets at time *t-1*. $Sales_{i,t-1}$ is the logarithm of sales value at time *t-1*. Time dummies are included in the estimates (coefficients are omitted in the table). Estimates are derived from the GMM system method developed by Blundell and Bond (2000) with moment conditions of endogenous variables starting from the period t-3 (t-2) for instruments in levels (differences) with finite-sample correction for the two-step covariance matrix developed by Windmeijer (2005). All regressions are estimated with an intercept term. Standard errors in round brackets. Degrees of freedom are in square brackets. Accounting variables are deflated using the consumer price index in 2005 as the reference year (source: Eurostat). * p < .10; ** p < .05; *** p < .01.

Figure A.1. Pattern of the inflation in the countries included in the VICO dataset (period 1996-2010)



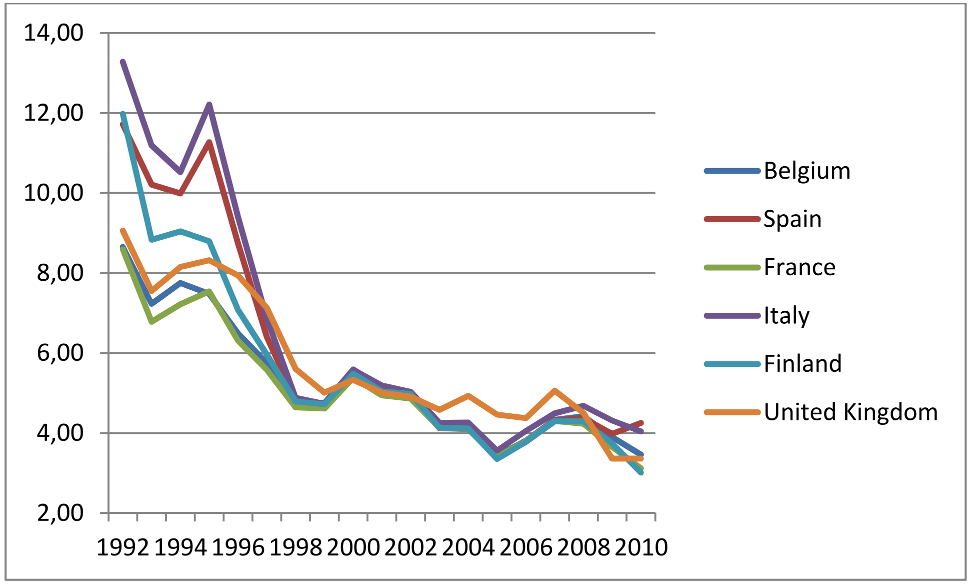
Legend. The consumer price index (CPI) measures the change over time in the prices of consumer goods and services acquired by households, as a proxy of inflation. CPI represents "the official measure of consumer price inflation in the euro-zone for the purposes of monetary policy in the euro area and assessing inflation convergence as required under the Maastricht criteria" (source: Eurostat).

Figure A.2. Pattern of the labor cost in the countries included in the VICO dataset (period 1996-2007)



Legend. The labour cost index (LCI) shows the short-term total cost on an hourly basis of employing labour, i.e. the cost pressure arising from the production factor "labour" (source: Eurostat).

Figure A.3. Pattern of the cost of capital in the countries included in the VICO dataset (period 1992-2010)



Legend. Interest rates for long-term government bonds based on central government bond yields on the secondary market, gross of tax, with a residual maturity of around 10 years (source: Eurostat).