VŠE / FACULTY OF INTERNATIONAL RELATIONS

Working Paper Series

Venture Capital and Growth of Young High-Tech Firms in the EU: A Systematic Review of the Empirical Evidence

Working Paper 2021 - 02

Smaranda Pantea
Marcel Tkacik

ISSN 2695-0820

Venture Capital and Growth of Young High-Tech Firms in the EU: A Systematic Review of the Empirical Evidence[1]

Smaranda Pantea[2] and Marcel Tkacik[3]

Abstract

This study contributes to the debate on VC-related policies that aim to support the growth of young high-tech firms in the EU. The study provides a systematic review of the results of 22 firm-level studies that estimate causal effects of VC using counterfactual impact evaluation methods and data from 12 EU countries. The results show a large preponderance of positive effects of VC on employment, revenues and assets growth and on reducing financial constraints, but mixed effects on innovation and other aspects of firm performance. They suggest that private VC tends to have larger effects than government VC, but that the latter plays an important role as a complement to private VC. The review finds supporting evidence for the two main channels highlighted by the literature: provision of financial resources and of non-financial resources (know-how and networks), although the evidence on the latter is scarce. Based on the results of the review and on the current landscape of VC in the EU, the study highlights important gaps in the literature and policy implications.

Keywords: venture capital, firm performance, start-ups, innovation, systematic literature review, European Union

JEL codes: G24, L25, M13, O31, O33, O52

[1] The work on this study was supported by the Internal Grant Agency of the Faculty of International Relations, Prague University of Economics and Business under the grant F2/42/2020. The authors thank Natalija Neskoroďana, Marek Pokorný and Zuzana Vrbková for excellent research assistance.

[2] Corresponding author, Prague University of Economics and Business, Faculty of International Relations, W. Churchill Sq. 4, 13067, Prague 3, Czech Republic, e-mail: smaranda.pantea@vse.cz

[3] Prague University of Economics and Business, Faculty of Business Administration, W. Churchill Sq. 4, 13067, Prague 3, Czech Republic, email: marcel.tkacik@vse.cz

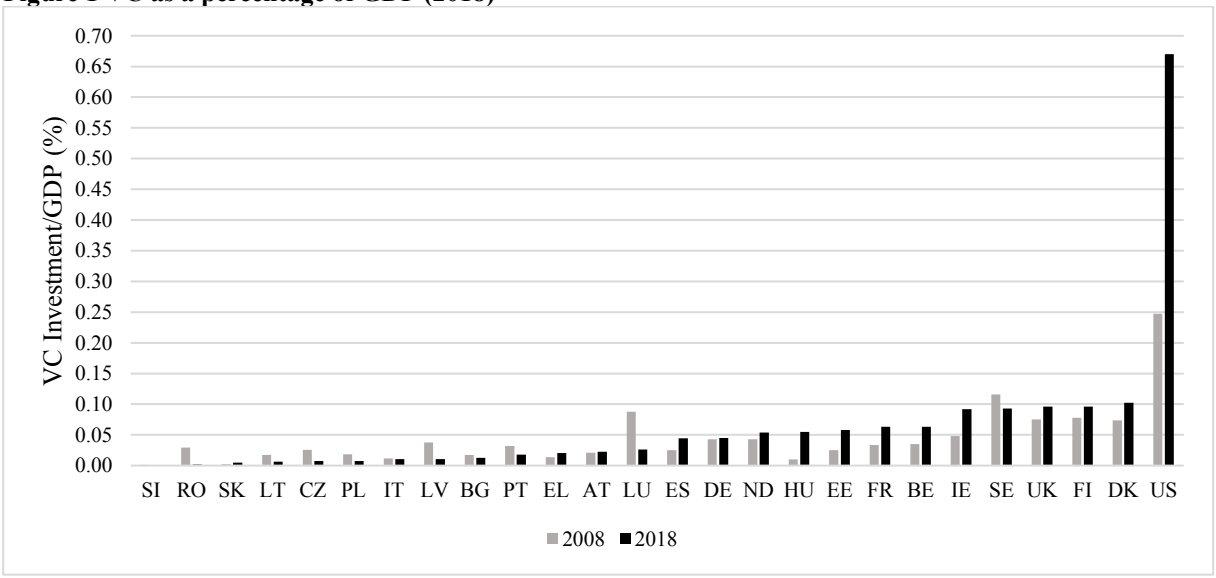
1. Introduction

Young firms in high-tech sectors are more likely than others to pursue radical innovations, which can raise productivity in all sectors through economy-wide technology spillovers (Aghion, 2017; Acs et al., 2018; Szerb et al., 2019). The smaller size and delayed development of the ICT sector in the EU compared to the United States (US) led to lower productivity growth and innovation in the EU (Van Ark et al., 2008). In this context, the EU has made increasing the share of firms in high-tech sectors and the share of firms that invest in innovation and R&D key objectives of the Europe2020 strategy (European Commission, 2010).

Venture capital (VC) has been highlighted as a key driver of the growth of young innovative firms in high-tech sectors (Nepelski et al., 2016; Aernoudt, 2017). VC is an essential source of external finance for these firms, given their limited access to other types of external finance. Additionally, VC investors may provide business know-how and access to their networks, which are important resources for a successful expansion process (Alexy et al., 2012; Autio et al., 2018). VC has played a major role in the development of the high-tech sector in the US and Israel (Senor & Singer, 2011), but in the EU, its roles has been more limited role.

VC markets in the EU have several distinctive characteristics compared to the US, which prevent the use of the results obtained by studies on the US as an-base for policy making. First, the EU attracts markedly less VC. In 2016, EU attracted 15% of the global VC investment, while the US attracted 70% (Nepeski et al., 2016). Figure 1 shows that EU countries attract less VC investment also relative to the size of their economies, and that, with few exceptions, these differences are not decreasing over time.

Figure 1 VC as a percentage of GDP (2018)



Notes: Structural and Demographic Business statistics, OECD.

Second, the VC market in the EU remains fragmented along national borders due to differences in legislation, the risk of double taxation and the "home bias" of the investors (European Commission, 2020; Botsari et al., 2019). Moreover, VC is highly concentrated: 90% of the VC investment and activity is concentrated in 10 EU countries (Nepelski et al., 2016). Third, while the finance gap in the EU is larger than in the US in all phases of the firm lifecycle, this gap is particularly large in the scale-up stage[4] (Aernoudt, 2017; Duruflé et al., 2017). Fourth, the thinness of the EU VC markets has negative effects on the selection of firms and investors into VC markets and on the quality of the matches between the two (Bertoni et al., 2016). Finally, unlike in the US, in the EU, there is large heterogeneity in the types of VC investors, with VC funded by governments[5] and other public institutions[6] playing important roles (Betoni et al., 2015a; Croce et al., 2015; Kreimer-Eis et al., 2016; Pavlova & Signore, 2019). They have different effects than private VC, which may contribute to the lower effects of VC in the EU.

As young firms tend to raise capital locally, these differences in the availability and heterogeneity of VC, result in fewer successful scale-ups in the EU and increased probability of high potential start-ups moving to US, with negative consequences for the size and competitiveness of high-tech sector in the EU (Aernodt, 2017; Duruflé et al., 2017; European Commission, 2020). Increasing the number of highly successful scale-ups is an objective of the new EU SME and Digital Strategies (European Commission, 2020; 2021). In this context, a variety of policies that aim to increase VC supply have been adopted, including, reductions in administrative barriers, tax incentives, creation of government VC and fund-of-funds and co-investment schemes. There is an ongoing debate on the effectiveness of these policies.

This study contributes to this debate by providing a comprehensive review of firm level studies that estimate causal effects of VC in the EU. It summarizes the results of 22 firm-level studies that estimate, plausible, causal effects of VC using counterfactual impact evaluation methods and data from 12 EU countries. The review finds a clear preponderance of positive effects of VC on employment, revenues and assets growth and supporting evidence for two main channels: reducing financial constraints and providing access to know-how and networks. The evidence on the effect of VC on innovation and other outcomes is mixed. Taken together, these results suggest that VC help innovative firms commercialize existing innovations, expand

[4] Duruflé et al. (2017) estimate that the average scale-up in the US received five times more VC than a comparable scale-up in the EU.
[5] In 2019, it accounted for 20% of all VC (Invest Europe, 2019).
[6] In addition to national and regional institutions, EU institutions, in particular, European Investment Fund plays an important role.

their markets and improve business processes related to expansion, but have limited impact on creation of new products and services. The review finds larger direct effects for private VC (PVC), than for government VC (GVC), likely due to their better business know-how, but the evidence suggests an important role for GVC as a complement to PVC.

This study relates to several existing reviews on VC (Peneder, 2012, Manigart & Wright, 2013; Rosenbusch et al., 2013; Tykvová, 2018a; Lohwasser, 2020). It differs from them by focusing on studies that analyze these effects in the EU context and on studies that estimate, plausibly, causal effects, which ensure policy relevancy. It also relates to Revest & Sapio (2012), who analyze different sources of external finance for high-tech firms, while this review provides a detailed survey of the evidence for one source - VC. The main contribution of this study is that it summarizes the most rigorous recent evidence on the effects of VC on funded firms in the EU and on their heterogeneity, depending on the different aspects of firm performance, channels and VC investor type. The results are informative for policies that aim to increase supply of VC and for identifying gaps in the literature.

The study is organized as follows. Section 2 describes the effects VC on funded firms and methodological challenges in their estimation. Section 3 describes the methodology of the literature review and the selection of the studies. Section 4 summarizes the main results of the review. Section 5 discusses the conclusions and policy implications of these results.

2. Conceptual context: VC effects and main empirical challenges

2.1. VC effects on funded firms

VC is a key source of finance for young innovative firms with limited access to external finance due to a lack credit history and suitable collateral, as they tend to rely more on intangible, firm-specific assets (Bertoni et al., 2010). They also tend to pursue innovation-centred projects, which are inherently riskier and are more difficult to evaluate. These characteristics lead to information asymmetry in credit markets, which limits their access to external finance.

VC investors can reduce this asymmetry by using effective screening procedures, developed based on their previous experience in evaluating such firms (Quas et al., 2020) and contract incentives and extensive monitoring procedures (Bertoni et al., 2010). In addition, VC investors can help decrease the information asymmetry for other financial institutions with more limited experience in evaluating such firms and projects. As the screening abilities of VC investors are well-known, receiving VC finance provides information about the potential of the funded firm for banks and other investors. Thus, VC, in addition to its direct effect, may

improve access to other types of external finance (Croce et al., 2013b; Bertoni et al., 2015; Bronzini et al., 2020).

VC investors often provide access to non-financial resources, such as business know-how (Alexy et al., 2012; Autio et al., 2018). VC investors, through their accumulated experience, have comprehensive knowledge of the relevant markets and general business expertise related to firm expansion and management of larger firms, which start-ups often lack. Expansion involves an increase in the complexity of business processes. VC investors provide advice on developing and implementing efficient administrative, recruitment, marketing, strategy and management procedures, which are needed for a professional management of a larger firm (Sørensen, 2007; Alexy et al., 2012; Luukkonen et al., 2013). They also provide access to their network of suppliers, customers, which are crucial for market expansion, and help the firms develop their own networks (Duruflé et al., 2017; Autio et al., 2018). Different types of VC investors differ markedly in the ability to provide such know-how and expertise. The ability to provide business expertise and access to networks depends on business experience and reputation of VC investors (Drover et al., 2017) and it represents a key difference between government and private VC investors (Grilli & Murtinu, 2014; Bertoni & Tykvová, 2015).

2.2 Main empirical challenges

VC investors select firms with high growth potential, which means that the observed higher performance of VC-backed firms may reflect two different effects: *"selection"* due to VC investors to picking best performing firms and *"value-added"*, given by provision of financial and nonfinancial resources (Bertoni et al., 2011; Croce et al., 2013; Grilli & Murtinu, 2014; Tykvová, 2018a; Quas et al., 2020).

A large literature, reviewed by Gompers & Lerner (2001), documents the VC investors abilities to screen and select firms with highest growth potential. In the European context, there is evidence that VC investors tend to select more innovative firms (Engel & Keilbach, 2007; Caselli et al., 2009; Peneder, 2010; Bock et al., 2018) and firms with better management teams (Engel & Keilbach, 2007; Colombo & Grilli, 2010; Bertoni et al., 2013a). However, Bertoni et al. (2011) and Croce et al. (2013) find no evidence of selection effects and Bertoni et al. (2013) find evidence that firms that receive VC tend to be more financially constrained.

For policy proposes, the effect of interest is the *"value-added"* effect of VC. To obtain unbiased estimates of this effect, the identification strategy has to separate the *"value-added"* effect of VC from the *"selection"* effect by using appropriate econometric methods and comparing firms that were otherwise similar before receiving VC. Therefore, the results of

studies that measure correlation between VC and firm performance and those that isolate *"value-added"* effect are not directly comparable.

To ensure comparability of the results, the focus on the most rigorous evidence available and policy relevancy, this review covers exclusively studies that use counterfactual impact evaluation methods to estimate *"value-added"* effects of VC.

3. Methodology and selection of articles

The literature on the effects of VC on firm performance examines different aspects of firm performance, including, firm size, innovation and exits. Additionally, there is large heterogeneity in the econometric methods used. In view of these considerations, a systematic literature review was considered more appropriate than a meta-analysis. We follow the methodology used in similar reviews, such as, Kresten et al. (2017), on access to finance for SMEs and Dvouletý et al. (2020) on the effects of public grants for SME.

The aims of the review are reflected in the search code used. The search code consists of five parts: the first part focuses on VC finance/investments, the second - on the EU and the EU members states, the third - on firm performance measures, the fourth - on the characteristics of the funded firms and the fifth - on the empirical methods used. The code is presented in Appendix 1. For better comparability and policy relevancy, the review covers only studies published in peer-reviewed journals after 2000. The focus on published research is motivated by the aim to concentrate on the most rigorous evidence available.

The code was applied to two most used academic databases within Social Sciences: Web of Science (Clarivate Analytics, 2020) and Scopus (Elsevier, 2020). The search took place between 28/02/2020 and 06/03/2020. After the removing the duplicates and merging the two searches, we obtained a total of 115 articles. For these 115 articles, the authors, independently evaluated the relevance of each article based on the abstracts. The abstracts were graded from 1 (least relevant) to 5 (most relevant). The criteria for the evaluation were based on the aims of the study and code discussed above. The mean and standard deviations were calculated for each study and only those with a score above 2.33 were kept. This reduced the list to 40 articles.

For these 40 articles, key information was extracted from the full text of the articles. The information extracted concerned: VC treatment, the country and period of the analysis, outcome variables, characteristics of the sample used, econometric methods used and the main findings. The relevance of the article for the aims of the study was assessed based on this information. The main reasons for exclusion were: the methodology did not address endogeneity of VC, the

analysis referred to countries outside EU, the study did not estimate the effect of VC, but of other types of finance, or the study was not at firm level.

At this stage, the references of these article and the journals in which these articles were published were also searched for additional relevant studies. Adding these articles, resulted in a list of 22 relevant studies. Key information extracted for these studies, including the main findings, is reported in Table 1.

4. Review of the studies

4.1. Characteristics of the sample of the studies

Journals

The selected articles were published in: *Small Business Economics* (5), *Research Policy* (4), *Journal of Business Venturing* (3), *Journal of Corporate Finance* (2), *European Financial Management* (2) and one in each of the following journals *Industry and Innovation, Journal of Empirical Finance, Journal of Technology Transfer* and *Venture Capital: An International Journal of Entrepreneurial Finance*.

Geography

The selected studies cover the following countries: Italy (13 studies), Spain (11 studies), Germany (9), Belgium (8), France (8), United Kingdom (8), Finland (7), and Austria, Denmark, Luxembourg, Norway, Portugal and Sweden (1). This geographical coverage reflects two aspects: the high concentration of VC activity in the EU[7] (Nepelski et al., 2016; Aernoudt, 2017; Duruflé et al., 2017) and data availability. Most studies are based on VICO dataset, which covers only seven EU member states. Additionally, countries with high quality national level datasets, like, Italy and Spain are more often studied.

This geographical coverage highlights a lack of the studies on CEE countries and on smaller EU15 countries. This is an important gap because in some of these countries, VC investment has increased rapidly after 2008 (see Figure 1) and currently plays an important role relative the size of their economy. Moreover, countries like Estonia and Ireland, have emerged as VC hotspots (Nepelski et al., 2016; Invest Europe, 2019) and their experience could be instructive for policy in other smaller countries. The results from the large and mature VC markets cannot be easily generalized to these countries due to smaller and thinner VC markets (Bertoni et al., 2016).

[7] 90% of the total number of VC-backed firms and the total VC investment is concentrated in only 10 EU member states (Nepelski et al., 2016).

Age

Most studies (18 out of 22) focus on young firms, although the definition of "young" varies considerably between firms less than 5 years old (Croce et al., 2019) to firms less than 25 years old (Corsi & Principe, 2020). There is a lack of studies on the effect of VC in very early stages of entrepreneurship process, likely, due to poor data coverage of very young firms in commercial databases and to the econometric methods used, which require firms to be observed for several years before receiving VC. Nevertheless, given the large share of VC going to very young firms[8] (Nepelski et al., 2016), it remains an important gap in the literature, which should be addressed by future studies.

Sector

Most studies (15 out of 22) focus exclusively on high-tech/knowledge intensive sectors or mention that these sectors represent a large share the firms in the samples used. Several papers cover all sectors, but indicate important concentrations in ICT sector, biotech and healthcare, or a focus on "research-based firms" or "new technology-based" firms. This is in line with the sectoral distribution of VC investment in the EU as described by Nepelski et al., (2016), Kreimer-Eis et al. (2016), Botsari et al. (2019) and Pavlova & Signore (2019).

Overall, the coverage of the studies mirrors the concentration of VC investment in the EU, which suggest that the conclusions are highly relevant at EU level. However, given the gaps highlighted, they should be regarded as representative, mainly, for young firms, after the very early stages of lifecycle, active in high-tech sectors in large, advance EU economies.

4.2. Outcome variables, VC treatment, research designs and methods

The selected studies focus on different aspects of firm performance: employment growth (10), sales/revenues growth (9), innovation (7), investment ratio (4), productivity growth (2), asset growth (2), positive exit (2) and debt ratio (2). Recognising the importance of different aspects of performance, in order to provide a more nuanced view of the effects of VC, the most recent studies tend to estimate the effects on several aspects.

VC treatment is most frequently measured as an indicator variable that shows whether a firm received VC. Several studies also distinguish between: between GVC and PVC (5),

[8] Nepelski et al. (2016) report that 36% of VC-backed firms in the EU were less than 2 years old.

between captive VC (CVC) and independent VC (IVC) (4), between bank VC (BVC) and IVC (1) and between PE and VC (2).

The most used econometric methods are: matching, based mainly on propensity score matching (11), generalize methods of moments (11), instrumental variables (5), fixed effects regression (4), difference and differences (3) and Heckman selection procedure (3). To address the different limitations of each method, there is a tendency in the most recent articles to report the results of several methods.

4.3. Empirical results

Firm growth

Employment growth is the most studied measure of firm performance. Likely, this reflects its policy importance and its reliability as an indicator firm growth (Delmar et al., 2003; Coad & Hölzl, 2012). Ten studies (Engel & Keilbach, 2007; Colombo & Grilli, 2010; Peneder, 2010; Bertoni et al., 2011; Bertoni et al., 2013a; Grilli & Murtinu, 2014; Croce et al., 2019; Bronzini et al., 2020; Quas et al., 2020) estimate the effect of VC on employment/payroll growth. All find positive effects, except Grilli & Murtinu (2014) and Bock et al. (2018), who find insignificant effects.

Other measures of firm size used are sales/revenue and assets. Seven studies (Caselli et al., 2009; Peneder, 2010; Bertoni et al., 2011; Bertoni et al., 2013a; Grilli & Murtinu, 2014; Quas et al., 2020) find positive effects of VC on sales/revenue growth, while three (Colombo & Grilli, 2010; Bock et al., 2018; Bronzini et al., 2020) find insignificant effects. Two studies (Bronzini et al., 2020; Quas et al., 2020) find positive effects of VC on assets growth.

Investment and financial constraints

Using standard investment regressions augmented with variables for VC, four studies (Bertoni et al., 2010; Bertoni et al., 2013b; Engel & Stiebale, 2014; Bertoni et al. 2015b) show that VC has a positive direct effect on investment and a negative effect on the dependence to internal cashflow. The later effect shows that receiving VC reduces financial constraints of the funded firms.

Morever, several studies also examine whether VC improves access to other sources of external finance by providing information about the unobserved characteristics of funded firms to banks and other investors. Bertoni et al. (2015), Croce et al. (2015) and Bronzini et al. (2020) find supporting evidence for access to bank credits.

Innovation

The most frequently used measure for innovation is the number of patents (Engel & Keilbach, 2007; Caselli et al., 2009; Arqué-Castells, 2012; Bertoni & Tykvová, 2015; Corsi & Principe, 2019; Bronzini et al., 2020) and probability of patenting (Engel & Keilbach, 2007; Arqué-Castells, 2012; Bronzini et al., 2020).

The results on innovation are mixed. Engel & Keilbach (2007) and Caselli et al. (2009) find insignificant effects of VC on the number of patents and on new or significantly improved products/services in the total sales revenue (Peneder, 2010). Arqué-Castells (2012) and Corsi & Principe (2019) find positive effects of VC on the number of patents. Several studies find mixed evidence depending on the type of VC (Bertoni & Tykvová, 2015; Bronzini et al., 2020). Overall, the evidence on the effect of VC on innovation is mixed.

These mixed effects may seem in contradiction with the evidence that VC select more innovative firms (Engel & Keilbach, 2007; Caselli et al., 2009; Peneder, 2010; Bock et al., 2018) and with positive correlation between VC and innovation documented at sector and macroeconomic levels. A possible explanation is that VC investors, mainly, help selected innovative firms expand the market for their innovations by providing finance and business know-how (Peneder, 2010; Duruflé et al., 2017). Thus, despite not increasing the innovativeness of firms, VC increases returns to innovation, which, depending on the importance of VC in the economy, may stimulate investment in innovation. This is in line with the finding of Popov and Roosenboom (2012), who find a relationship between VC and innovation only in VC countries with higher shares of VC.

Other indicators (productivity, profitability, exit)

Evidence on other performance indicators is scarce and the results are mixed. Bronzini et al. (2020) find an insignificant effect on survival and Cumming et al. (2017) find that positive effect on the probability of a positive exit, defined as IPO or trade sale, but only for IVC. For productivity, Croce et al. (2013) find positive effects on TFP, while Alperovich et al. (2015) find negative effects for GVC and positive effects for PVC on an efficiency index. Bronzini et al. (2020) find initial negative effects of VC on profitability and credit score, which in time become insignificant, and insignificant effects on wages. The results for profitability are in line with Pavlova & Signore (2019), who argue that VC-backed firms tend to prioritize long-term growth over short term profitability.

4.5 Heterogeneity

VC investors

VC investors differ in their objectives which affects how they select the firms in which they invest. GVC investors tend to give a larger weight to social goals, like, job creation or supporting firms in lagging regions, while IVC and PVC investors focus on strategic and financial performance and therefore select firms based on their growth potential (Bertoni et al., 2010; Croce et al., 2019). GVC and IVC/PVC also differ in the type of resources they provide. Both provide access to financial resources, but GVC are less likely to provide business know-how and access to networks than PVC investor due to their different business experience and expertise (Bertoni et al., 2013; Bertoni & Tykvová, 2015).

The evidence on the direct effects of GVC is mixed. Alperovych et al. (2015) find negative effects on efficiency. Several studies find insignificant effects on sales (Grilli & Murtinu, 2014), positive exits (Cumming et al., 2017) and innovation (Bertoni & Tykvová, 2015). Croce et al. (2019) find positive effects on employment, although the magnitude of the effects relative to private VC varies depending on the phase of the business cycle.

Several studies find that syndicates of GVC and PVC, have larger positive effects than only PVC (Grilli & Murtinu, 2014; Bertoni & Tykvová, 2015; Cummings et al., 2017). These results suggest that GVC could play an important role in complementing and enhancing the effect of private VC. There is also evidence that receiving GVC can enable funded firms to attract private VC (Alperovich et al., 2020).

Several studies examine the different effects of independent VC (IVC) compared to captive VC (CVC). Most of studies find that IVC has a larger effect on the sensitivity of investment to cashflow (Bertoni et al., 2010), employment and sales growth (Bertoni et al., 2013a), firm growth and innovation (Bronzini et al., 2020). Croce et al. (2015) find that bank VC (BVC), which accounts for an important share of VC in the EU, decreases the probability for default and increase debt more than IVC.

Overall, most of the evidence suggest that GVC and captive VC tend to have lower direct effects, but that GVC plays an important role as a complement for private VC.

Country characteristics

Country characteristics, like the legal framework (Tykvová, 2018a) and financial development (Corsi & Precipe, 2019) may influence the effects of VC. The studies reviewed find positive effects of VC in countries with highly developed capital markets (UK, Germany, France) and in those with less developed capital markets (Austria, Italy and Spain), but the EU

countries with less developed capital markets were not covered by any study. While seven studies use a multicounty setting, they do not examine how country characteristics influence VC effects. A notable exception is Corsi & Principe (2019) who find a larger effect of VC in countries with less developed capital markets, thus, suggesting an important role for VC as a substitute for other types of finance.

Studies focused on different international contexts show that the country characteristics, such as, legal framework and taxation (Popov and Roosenboom, 2013; Tykvová, 2018b) affect the magnitude of the effects of VC. The importance of country characteristics is also emphasized by policy reports (Nepelski et al., 2016) and by the broader literature on entrepreneurship on the growth of young innovative firms (Acs et al., 2018; Autio et al., 2018). Overall, this remains an under-researched area.

Financial and nonfinancial resources

Most studies reviewed focus on the overall effect of VC investments on firm performance, without examining the channels though which it takes place. Few studies attempt to disentangle the two effects and those that do examine them separately, thus, making it difficult to draw conclusions about their relative importance.

Several studies focus exclusively on the provision of financial resources and find evidence of VC playing an important role in reducing dependence on internal resources (Bertoni et al., 2010; Bertoni et al., 2013b; Engel & Stiebale, 2014; Bertoni et al., 2015; Croce et al., 2015).

Only two studies (Bronzini et al., 2020; Quas et al., 2020) provide evidence on the importance on business know-how and other nonfinancial resources provided by VC investors. They compare VC-backed firms to firms that received comparable finance from other sources and find a significant effect of VC on firm expansion, consistent with the importance of nonfinancial resources provided by VC. This argument is further supported by evidence of larger effects of more experienced VC investors, who tend to have more business expertise (Quas et al., 2020).

5. Conclusions and policy implications

Supporting the growth of high-tech start-ups by increasing supply of VC investment is at the heart of many VC and innovation related policies in the EU. This study contributes to the debate on the effectiveness of these policies by summarising the results of empirical studies that estimate, plausibly, causal effects of VC on firm performance in the EU. This focus ensures that

effects estimated are comparable and that the conclusions are based on the most rigorous evidence available.

The review shows that, even after accounting for the endogeneity of VC, there is a large preponderance of evidence of positive effects of VC on firm expansion, but mixed evidence on the effects on innovation and other aspects of firm performance. Taken together, these results suggest that, in the EU, VC investors tend to select the most innovative firms and help them commercialize their innovations, expand their markets and improve business processes associated with firm expansion. Regarding different types of VC, the evidence points to lower and sometimes insignificant effects from GVC compared to PVC, but positive effects of GVC when it complements PVC.

In view of the objective to support young innovative firms (European Commission, 2010, 2020) and the, relatively, low supply of VC in the EU, these results indicate a need for policy support for VC. While the evaluation of different policy instruments is beyond the scope of this paper[9], the results of the review have several policy implications. First, they suggest that all types of VC have positive effects on the expansion of young innovative firms, thus, lending support to policies that emphasize improving the business environment for all types of investors and, in particular, those that aim to increase supply of VC. Second, the results of the studies on government VC, suggest that this type of VC tends to have lower effects on its own, but large effects when it complements private VC, thus, lending support to policies that focus on this complementarity. Finally, the analysis of the coverage of the studies reviewed suggest that there is a need to improve data availability and quality for the countries not covered by the existing studies and also for very young firms in all countries.

The review highlights several gaps in the literature. First, more evidence is needed on smaller countries, with less developed VC markets, and on how country characteristics affect VC effects. Second, there is a lack of evidence on the effects of VC on start-ups in the very early stages of entrepreneurial process, despite such investments representing a large share of the VC investment. Third, despite high policy interest, there is limited evidence on cross border VC investments. Extending, Devigne et al. (2013) research on the effects of domestic and international VC using counterfactual evaluation methods would be an important avenue for future research. Finally, there is limited evidence on the channels through which VC investments affect funded firms. Providing evidence on the relative importance of different channels would provide a useful extension of the literature.

[9] Aernoudt (2017) and Alperovich et al. (2020) provide detailed discussions on advantages and disadvantages of different policies.

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Table 1 Review of empirical studies on the effect of VC on performance of funded firms

Study	Country of analysis	Period of analysis	VC indicator	Sample characteristics	Outcome Variables	Empirical Methods	Main results
Engel & Keilbach (2007)	Germany	1995-1998	VC	142 VC-backed and 21375 non-VC-backed young firms.	patent applications, probability of patent application, employment growth.	matching (PSM)	Insignificant effects on patent applications and probability of patent application, but positive effect on employment growth
Caselli, Gatti & Perrini (2009)	Italy	1995-2004	VC	37 VC-backed and 37 non-VC-backed firms.	patents, sales growth	matching (PSM)	Insignificant effect on the number of patents and positive effect on sales growth
Colombo & Grilli (2010)	Italy	2000-2004	VC	46 VC backed and 393 non-VC-backed new technology-based firms in high tech sectors.	employment and sales growth	Heckman selection model, IV, Control Function.	Positive effect on employment and sales growth
Bertoni, Colombo & Croce (2010)	Italy	1994-2003	IVC, CVC	52VC-backed (19 IVC, 33 CVC), 327 non-VC-backed and new technology-based firms.	investment	GMM	Positive effects on investment for both IVC and CVC, but only IVC has a negative effect on the sensitivity of investment to internal cashflow.
Peneder (2010)	Austria	2002-2005	VC	209 young firms (VC-backed and non-VC-backed)	employment and sales growth, ratio sales from innovation/total sales	matching (PSM)	Positive effects on employment and sales growth, but insignificant effect on innovation
Bertoni, Colombo & Grilli (2011)	Italy	1994-2003	VC	58 VC-backed and 481 non-VC-backed new-technology-based firms in high-tech sectors.	employment and sales growth	GMM, GMM, Heckman selection	Positive effects on employment and sales growth.
Arque-Castells (2012)	Spain	1999–2008	VC	233 VC-backed and 91381 non-VC-backed firms focused on innovation.	probability of patenting, patents	DiD, probit, Poisson	Positive effects on probability of patenting and on number of patents. The effect is largest in the first two years.
Bertoni, Colombo & Grilli (2013)	Italy	1994-2003	IVC and CVC	23 IVC-backed, 24 CVC-backed and 484 non-VC-backed new technology-based firms	employment and sales growth	GMM	Positive effects of both IVC and CVC on employment and sales growth in the long run. IVC has higher effects in the short run.

Bertoni, Ferrer & Martí (2013)	Spain	1995-2004	VC and PE	246 VC-backed and 78-PE backed unlisted firms, in low/medium tech manufacturing and services.	investment	GMM, GMM, FE, Hausman–Taylor regression	VC has negative effects on the sensitivity of investment to internal cashflow, while PE has the opposite effect.
Croce, Martí & Murtinu (2013)	Belgium, Finland, France, Italy, Spain, United Kingdom	1984-2010	VC	267 VC-backed firms and 429 non-VC-backed young, independent firms in high tech sectors	TFP, labour and capital productivity growth	FE, GMM, matching (PSM)	Positive effects on TFP and capital productivity, but insignificant results for labor productivity.
Grilli & Murtinu (2014)	Belgium, Finland, France, Germany, Italy, Spain, United Kingdom	1994-2014	IVC, GVC and IVC and GVC syndicate	538 IVC-backed, 239-GVC-backed and 126 backed by syndicates of GVC and IVC, matched to the same numbers of non-VC-backed firms.	employment and sales growth	Matching (PSM), FE, GMM	Positive effect of IVC and insignificant effect of GVC and of syndicates of IVC and GVC, unless led by IVC on sales growth. Insignificant effects of all VC variables on employment growth.
Cumming, Grilli & Murtinu (2014)	Belgium, Finland, France, Germany, Italy, Spain, United Kingdom	1991-2010	IVC, GVC and IVC and GVC syndicate	8370 companies, out of which 759 VC-backed, young, born independent, high tech firms	positive exit, defined as IPO or trade sale	multinominal logit model, matching (PSM), IV	Positive effects of IVC and of syndicates of IVC and GVC on the probability of a positive exit and insignificant effects of GVC on the probability of positive exits.
Engel & Stiebale (2014)	FR, UK	2000-2007	PE	18085 (2797 PE-backed) in France and 7543 (2239 PE-backed) in the UK.	investment	GMM	Positive effects of PE on investment and negative effect on the investment sensitivity to internal cashflow. The effects hold for both countries and are larger for SMEs than for large firms.
Alperovych, Hübner & Lobet (2015)	Belgium	1998-2007	VC, GVC, PVC	515 VC-backed (272 - PVC-backed and 243 - GVC-backed) and 515 non-VC-backed, young entrepreneurial firms.	productivity/efficiency index	matching (PSM)	Positive effect of PVC and negative effect of GVC.

Croce, D'Adda & Ughetto (2015)	Belgium, Finland, France, Germany, Italy, Spain, United Kingdom	1994-2004	BVC and IVC	51 BVC-backed firms matched to 332 non-VC backed firms matched to BVC-backed firms and 77 IVC-backed firms matched to 402 non-VC backed high tech entrepreneurial firms.	the default probability and debt.	matching (PSM)	Positive effect of BVC on decreasing distress probability and on debt. Insignificant effects for IVC on both outcomes.
Bertoni & Tykvová (2015)	Belgium, Finland, France, Germany, Italy, Spain, United Kingdom	1984-2010	GVC and IVC	665 (125 VC-backed and 540) young start-ups in a high-tech sector (biotechnology).	patents, patents adjusted for quality	FE, GMM	Insignificant effect of GVC and positive effect of IVC on patents. GVC has a positive indirect effect, as complement to IVC.
Bertoni, Croce & Guerini (2015)	Belgium, Finland, France, Germany, Italy, Spain, United Kingdom	1995-2004	VC	128 VC-backed and 233 non-VC-backed young high-tech firms.	investment	matching (PSM), GMM.	Negative effects on investment cashflow sensitivity. The relationship is not linear and the effect is significant only for follow-on rounds of VC.
Bock, C., Hübner, A., & Jarchov, S. (2018)	Germany	1998-2012	VC	98 research-based spin-offs o (31 out of it were VC-backed)	employment and sales growth	IV, Heckman selection model.	Insignificant effect on employment and sales growth
Croce, Martí & Reverte (2019)	Spain	2005-2013	PVC and GVC	73 GVC-backed, 211 PVC-backed and 888 non-VC, young entrepreneurial firms.	employment growth	matching (PSM), IV, GMM	Positive effects for PVC and GVC on employment growth. PVC effect was higher during the crisis, while GVC was higher before the crisis.
Corsi & Prencipe (2019)	Belgium, Denmark, Finland, France, Germany, Italy, Luxembourg, Norway, Portugal, Spain, Sweden, United Kingdom	2009-2013	VC/PE	326 (223 firms non-VC/PE-backed and 103 VC/PE backed) young SMEs in medium-high and high-tech manufacturing.	patents	Poisson quasi likelihood, IV	Positive effect of VC/PE. The effects are larger in countries with less developed capital market and less developed entrepreneurial culture.

Bronzini, Caramellino & Magri (2020)	Italy	2004-2014	VC, IVC and CVC	101 VC-backed and 258 non-VC-backed start-ups. The non-VC-backed startups, had sought VC and were rejected in late stages of VC screening.	survival, assets, labor costs, sales, employees, wage, profitability, probability of patent application, number of patent applications, credit score, financial structure	DiD	Positive effect on assets, labour costs, number of employees, innovation, equity and debt. Negative effects on profitability and credit score. Insignificant effects on sales, survivorship and wages. Positive VC effects on size and innovation are driven by IVCs, while the effect of CVC is insignificant.
Quas, Martí & Reverte (2020)	Spain	2005-2013	VC	515 VC-backed, 1551 non-VC-backed, beneficiating from participative loans young SMEs	employment, sales, assets growth	DiD, matching (PSM, CEM), GMM.	Positive effects on sales, assets and employment growth. Experienced VC investors have a larger effect on firm growth.

Note: Table 1 is sorted in chronological order of the studies. The abbreviations in the table stand for: PSM – propensity score matching, GMM - generalized method of moments, FE – fixed effects regressions, TFP - total factor productivity, IV - instrumental variables, DiD – difference-in-differences, CEM – coarsened exact matching.

Appendix 1

Search code

1)Treatment (abstract/title/keywords):

"Venture capital" OR VC investment*" OR "VC investor" OR "VC fund*" OR "VC financ*" OR "VC*backed" OR "seed funding" OR "initial VC" OR "funding round*" OR IVC OR GVC "government* venture capital" OR IVC OR "independent venture capital" OR CVC OR "corporate venture capital" OR "syndicated investments"

2)EU MEMBER STATES (28 countries)

AND (anywhere)

Austria* OR Italy* OR Belgium* OR Latvia* OR Bulgaria* OR Lithuania* OR Croatia* OR Luxembourg* OR Cyprus* OR Malta* OR Czech* OR Czech Republic* OR Netherlands* OR Holland* OR Denmark* OR Poland* OR Estonia* OR Portugal* OR Finland* OR Romania* OR France* OR Slovakia* OR Germany* OR Slovenia* OR Greece* OR Spain* OR Hungary* OR Sweden* OR Ireland* OR United Kingdom* OR "European Union" OR "EU" OR "Europe" OR "European"

3) FIRM CHARACTERISTICS

AND (anywhere)
"start up" OR "start-up" OR "startup" OR "young firm" OR "new firm" OR "innovative firm" OR "high tech" OR "high-tech" OR "IT" OR "ICT" OR "tech" OR "new technology-based firm" "NTBF" OR "knowledge intensive" OR "innovation"

4) OUTCOME VARIABLES:

AND (anywhere)

"firm growth" OR "firm performance" OR "economic performance" OR revenue* OR turnover OR sales OR "value added" OR "value-added" OR employment OR employee* OR productivity OR "scale-up" OR "scaleup" OR "scaling up" OR assets

5) METHODS

AND (anywhere)
"counterfactual evaluation" OR "treatment effect" OR "causal effect" OR "propensity score" OR "matching" OR "regression discontinuity" OR "dif-in-dif" OR "difference-in-differences" OR "difference in differences" OR "instrumental variable*" OR "identification strategy" OR "GMM" OR "Generalized Method of Moments"