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Direct and Indirect Effects of Private- and Government Sponsored Venture Capital

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Direct and indirect effects of private- and government sponsored venture capital

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Abstract

This paper studies the real effects of venture capital on targeted firms. Specifically, using a unique dataset with comprehensive information on private- and governmental venture capital investments, we examine the effects of such investments on firms' sales, employment and investments in physical capital. The results suggest that both private and public venture capital boost firm sales two to three years after the investment. The sales increase can, in turn, partially be traced to an investment effect, and partially to increased efficiency, whereas no employment effects are found. Finally, our findings suggest that government investors are more prone than private VC firms to make follow-up investments in stagnating non-growing firms.

JEL Codes: C21; C23; D22; G24; G28; L25; L26; H44

Keywords: Venture capital; Start-ups; Firm growth; Investments; Governmental venture capital

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1. Introduction

Since the millennium, government-sponsored VC (GVC) has become an increasingly popular instrument for promoting growth and investments among innovative SMEs. In Europe, governments now provide about one third of all VC raised (Invest Europe, 2016). Based on these observations, one might presume that the growth effects of GVC interventions are well analyzed and understood. However, surprisingly little is still known about their impact on the economy as a whole, and more specifically whether the companies receiving investments respond differently to private and governmental sponsored venture capital. It is also unclear if the size of the GVC market corresponds to a market failure of the same magnitude.

One motive for government to intervene in the VC market is that the financial market, at least in theory, is endowed with an undersupply of external capital. This leads to a so-called funding gap that mainly affects young and innovative firms (Lerner, 2002). Typically, these firms have little (if any) cash flow or collateral to pledge for credit. With a high risk of failure, traditional forms of financing such as bank loans are rarely an option (Hall and Mairesse, 2008; Berger and Udell, 1998; Carpenter and Petersen, 2002). Many young and innovative firms instead turn to VC investors to finance their businesses (Gompers and Lerner, 2001; Colombo and Grilli 2010; Chemmanur et al. 2011; Puri and Zarutskie 2012; Croce et al. 2013). Because of the inherent risk and uncertainty that pervade for young innovative firms, coupled with a substantial fixed cost accompanied with VC investments, the supply of private VC is limited. As a result, private VC is scarce and may be unable to fully remedy the funding gap for start-ups. This is problematic because the same companies play a critical role as important sources of job creation (Puri & Zarutskie, 2012), productivity growth (Chen et al, 2013), and new innovations (Kortum and Lerner, 2000; Cumming and Johan, 2016). To ensure the well-functioning of the economy, bridging the funding gap and helping to provide a continuous financing ladder throughout a start-up's lifecycle have become important objectives for policy makers (OECD, 2006).

The VC model is widely recognized as successful. On the one hand, receiving venture capital has been shown to exert a lasting imprint on the targeted companies. While VC constitutes a direct investment in the equity of the targeted companies, the attractiveness of

VC also derives from the access it provides to relevant business networks and the investor's expertise (Hellmann and Puri, 2012). Compared to similar firms that do not receive VC, VC backed companies experience, on average, higher employment and sales growth (Davila et al., 2003; Bertoni et al., 2011; Puri and Zarutskie, 2012), productivity growth (Chemmanur et al., 2011; Croce et al., 2013), better ability to generate patents (Brander et al., 2010), and a higher likelihood of going public (Puri and Zarutskie, 2012). On the other hand, the effect of VC can also be traced to the country level (Buera et al., 2011). One example is the higher level of R&D spending (public and private) in the US (2.6% of GDP) compared to in the EU (2% of GDP), which is believed to reflect the relatively small European VC market (European Commission, 2010; p.22).[2] To close the European-US VC gap, the European Commission implemented the Risk Capital Action Plan in in 1998 (European Commission, 1998) to stimulate stock market openness, increase the flexibility of labor markets, and provide a set of tax incentives. Further initiatives are currently being undertaken by the EU and by governments around Europe encouraged by the Europe 2020 agenda to make *"an efficient European venture capital market a reality"* (European Commission, 2010, p.22), including the recent announcement of a €1.6B venture capital fund. These efforts have led to a unique situation in Europe with a large number of government-sponsored VC investors (GVCs).

GVCs are VC companies that are either partly subsidized or entirely owned by the government. They enter the VC market directly by increasing the supply of VC in industries where the flow of private VC investments is believed to be thin.[3] The increased presence of GVCs has triggered a debate about the role of GVCs and the appropriateness of their investments, along with a growing literature that seeks to evaluate GVC performance against both the PVC's and the GVC's own objectives.

In light of the funding gap, the motivation for GVC intervention in the VC market is strongest for the earliest stages of a firm's development (seed and start-up), where private

[2] Within the EU, the size of the VC market differs widely between countries (Groh and Lieser, 2010). This heterogeneity is often attributed to a chicken-egg paradox of developing VC markets, which states that the lack of VC depends on the lack of innovative ventures, and vice versa. For this reason the supply of private VC in many countries is likely below its potential, thus further aggravating the funding gap.

[3] As a supply-side intervention (Colombo et al., 2016), GVC should be distinguished both from other government programs that indirectly seek to increase the supply of VC and from subsidies or grants that target the same group of firms (Grilli and Murtinu, 2014), but do not provide the same incentive and monitoring schemes.

alternatives are most likely to be scare (Lerner, 2002; Colombo et al., 2016; Svensson, 2011; OECD, 2006). When surveying the Swedish GVC market, Svensson (2011) finds, on the contrary, that GVCs mostly invests in later stages. The same conclusion was reached by Swedish National Audit Office (Riksrevisionen, 2014), who pointed to several inefficiencies in the Swedish system with multiple GVCs having different profiles and an unclear division of labor between them. [4] Regarding the effects of GVC on the recipient companies, previous scholarly literature finds that these firms do not develop as strongly as firms backed by PVC in terms of the generation of patents, firm growth and productivity. When it comes to the mechanisms by which GVC along with PVC impact the firms, the previous literature provides little if any guidance.

This paper contributes to this literature in a number of ways. First, with access to a unique and comprehensive dataset of VC investments that covers a large share of PVC investments and virtually all investments made by the six largest GVC investors in Sweden made between 2007 and 2014, combined with data on the finances of the recipient firms, we provide additional evidence on how PVC, GVC and MVC (Mixed VC – a combination of PVC and GVC) affect sales, capital investments and the hiring of new employees. Second, to unpack the black box of how VC investments impact the recipient firms, we consider a structural model that accounts for both direct and indirect effects on firm sales, where the indirect effects work through investments in capital and employment. This allows us to not only better capture an overview of the effects of VC on firms, but also provide an empirical framework for studying the transmission mechanisms of VC in the recipient firms.

The results of this study can be summarized as follows:

- Firms that receive any form of VC increase their sales two-three years after the VC injection.

[4] An early analysis of the Swedish GVC market was undertaken by the Parliamentary Audit Office (1996). It found that most GVC investments had been failures and that the GVCs lacked knowledge and skills in board work and management. The analysis also found that GVC investments were used to maintain employment in otherwise non-competitive firms. At present, there is an ongoing GVC reform that seeks to direct focus more on the early investment stages and increase coordination with private investors (SOU, 2015:64; Prop., 2015/16:110).

- The increased sales are driven by increased investment and efficiency gains while there are no signs of any employment effects.
- Comparing investments from PVCs and GVCs, we find no indications that the effects are significantly different from each other.
- However, we find some indications that GVCs are more prone than PVCs to make follow-on investments in stagnating, non-growing firms.

The remaining chapters of the paper are structured as follows: Section 2 provides an overview of the theory of motivating GVC intervention. In Section 3 we review the recent empirical literature. Section 4 presents the data and Section 5 discusses the matching methods and econometric modeling. In section 6 we turn to the results followed by a robustness analysis in Section 7. In the final section we conclude with a discussion and a summary of our main findings.

2. Theory of government venture capital

Government intervention in financial markets can be motivated by the existence of capital market failures that give rise to a funding gap. This failure is often attributed to the asymmetry of information between the entrepreneur and the investor. To protect business secrets, entrepreneurs are unwilling to disclose certain information concerning technology or business operations. However, if there is a lack of information, investors are confronted by a significant hurdle in the form of a transaction cost that can lead to problems of adverse selection and moral hazard (Lerner, 2002; Akerlof, 1970). Even if the entrepreneur is transparent, it is difficult and costly for investors to evaluate the start-up and determine its chance of success (especially in the case of new technologies), and the risk of failure is typically deemed to be high. Furthermore, young ventures often have limited cash flow or assets that can be pledged as collateral. For these reasons, traditional financiers are often reluctant to extend credit to innovative start-ups.[5]

[5] On the one hand, investors are unwilling to provide funding unless the entrepreneur fully discloses information about his innovation. On the other hand, the entrepreneur is not willing to disclose all information to the investor, who could then steal the idea for himself, leading to a "double trust dilemma" (Cooter and Schäfer, 2012).

Conversely, VCs are especially well equipped to resolve this principal-agent problem through a regimen of screening, contracting and monitoring (Kaplan & Strömberg, 2001). Screening refers to an evaluation of the entrepreneur before an investment is made. Contracting provides incentives for the entrepreneur to maximize performance, such as an agreement to match the investment with his or her own funds. Monitoring refers to supervising the entrepreneur after investing, which often involves taking a seat on the board and overseeing the financial performance and providing access to business networks.

Although private venture capitalists (PVCs) can bridge some of the funding gap, there are reasons to believe that their effort is insufficient. Young VC markets are one example of this situation. Such markets are associated with the chicken-egg paradox (Gilson, 2003), which holds that the VC shortage is caused by the lack of innovative firms, which in turn could be caused by a lack of VC (Grilli and Murtinu, 2014). As a result, the total amount of VC is inadequate to fully remedy the shortage of financial capital demanded by young, innovative firms. If the lack of VC depends on too few innovative start-ups, government can intervene to catalyze the development of an active VC market. According to Lerner (2010), the externalities generated by investments from government venture capitalists can be particularly powerful in an undeveloped market because such investment helps build the institutional framework, including VC, needed for a thriving start-up ecosystem. Once the appropriate institutions for the VC market have been established, the positive externalities caused by GVC diminish (Guerini and Quas, 2016).

A lack of VC funds could also occur in developed VC markets, where the dearth is most pronounced for youngest ventures (Lerner, 2002). It is well known that a large share of start-ups fail (Coad et al., 2013). Because PVCs spend considerable resources on screening and supervising/coaching, each investment is associated with a high fixed cost, which combined with the high risk of failure make seed and early stage investment less attractive. Many PVCs also manage large funds and therefore prefer larger investments, making the fixed costs associated with such investments unjustifiable (Svensson, 2011). Furthermore, the time horizon until the potential return from investments in earlier stages is longer, which also makes these investments less attractive. The persistence of a financing gap for the very youngest firms could thus motivate GVC intervention to help provide a continuous financing ladder (sometimes referred to as the financing *chain*) throughout a start-up's life cycle.

GVC can also be motivated based on the “social returns” that accrue from entrepreneurship and innovations, which are larger than the private returns captured by investors. Seen from this perspective, GVCs are an instrument for the government to increase innovation and entrepreneurial activity to a socially optimal level. Finally, there is an argument that GVC should play a counter-cyclical role to PVC, smoothening macroeconomic fluctuations in the supply of PVC (Gompers and Lerner, 2003; Robinson and Sensoy, 2013; Lerner & Watson, 2008). Despite the inefficient market solution that is alleged to characterize VC markets, there are several criticisms related to the appropriateness of GVC increasing the supply of VC. A major critique of GVC’s intervention is that it can displace or *crowd out* PVC investment, if GVC competes with PVC for the most attractive investments. Because GVCs spend public funds, crowding out would at best only replace private investments, which is merely wasteful. In the worst case, however, GVC could result is a *reduction* in the total supply of VC.

More generally, GVCs can be criticized on the same grounds as government corporations generally, i.e., that they are inefficient. Government tends to be less efficient at providing a given good or service compared to a private business that has strong performance incentives (Colombo et al., 2016). Applied to GVC, inefficiency can arise both because GVCs are not as handsomely rewarded as their private counterparts and because they do not face the same downside in the case of failure. Furthermore, after making their investment, GVC managers may be less concerned about monitoring their portfolio firms to ensure that the funds are used as efficiently as is demanded by private investors. GVCs might also devote less effort to minimizing bureaucracy and making their organizations efficient. Finally, even if they do their best, government officials may be less capable investors than their private sector counterparts.

In addition to efficiency-related issues, there is also a risk of corruption and cronyism. Without adequate supervision, individuals may abuse their control of public funds to benefit themselves or their cronies instead of working for the common good. Lerner (2009; 2010) documents a series of examples of incompetence, wasted resources, and corruption associated with GVC programs. On the political side, Florida and Smith (1993) argue that GVC can be a way for politicians to compensate for failures in other policy areas and that introducing another political failure could make the outcome worse than the initial situation.

3. Review of the empirical literature

The empirical VC literature can be classified into a few broad topics. Of the studies that examine the performance of VC-backed companies, we distinguish between studies that investigate the effects of general VC from studies that look at the effects of PVC, GVC and MVC (i.e. for companies receiving both PVC and GVC) investments separately.

Productivity

While PVC and VC investments in general have been found to positively impact the productivity of the firms that receive funding (Chemmanur et al., 2011; Croce et al., 2013) the productivity effects from receiving GVC is less clear. In examining productivity growth among a sample of VC-backed US firms, Chemmanur et al. (2011) find that VC-backed firms are more productive on average at the time when they receive their first investment compared to other similar firms that do not receive an investment. In this case, the difference in productivity can be attributed to the screening made by PVCs when deciding which firms to invest in. They also find that VC-backed firms experienced higher productivity growth for up to four years after the initial investment, which is taken as evidence for a “value added” effect stemming from the services provided by the PVCs, which help make the firms more productive. Similar results are found for the productivity of VC backed European firms, but with no evidence of a screening effect (Croce et al., 2013). However, when looking at the productivity effects attributed to GVC alone, Alperovych et al. (2015) e.g. find that it leads to a significant *reduction* in the productivity of 515 Belgian firms, in contrast to a positive effect of PVC.

Employment and sales

Positive productivity shocks can also boost labor demand (in the form of new hires), and subsequent sales. The relationship between VC investment and employment and sales growth is the focus of another series of papers. Bertoni et al. (2011) find a positive effect for sales growth among 537 Italian “new technology-based firms” on the relationship between firm growth and following VC investments. In a similar vein, Davila et al. (2003) analyzed short-term employment growth among 500 VC-backed firms in Silicon Valley. Not only do firms experience significant employment growth prior to receiving VC investment, they find that that growth accelerates in the ensuing months.

Looking at the growth effects from PVC and GVC individually, there appear to be some differences. Early studies focused on the American Small Business Investment Research (SBIR) program that was not strictly structured as GVC but instead as a research grant (Audretsch et al., 2002; Gans and Stern, 2003; Wallsten, 2000; Lerner, 1999). Learner (1999) e.g. studied the employment and sales growth of 900 high-technology firms that participated in the program during 1985-1995. He found that the firms participating in the program grew faster than a control group of similar firms outside of the program, provided the companies were based in areas with substantial VC activity. In a recent study, Grilli and Murtinu (2014) find no evidence for sales growth among GVC-backed firms, whereas MVC- and PVC-backed firms experienced significant sales growth following an investment. There was, however, no evidence for significant employment growth from any type of VC investment (PVC, GVC, or mixed).

Exits and patenting

The primary means by which VCs can realize a successful investment is by selling their shares in the company either to another investor or via an IPO, what is known as "exiting" the investment. An alternative way to gauge firm performance is therefore to look at exit performance and survival rates of the targeted firms. If a company fails, there is no return for the VC to reap. In a study of more than 10,000 US firms that received VC, Puri and Zarutskie (2012) observe that during the first years after receiving VC, VC-recipient firms were less likely to fail compared to a control group of non-VC-recipient firms. As time went by, however, the difference in exit probability subsides.

Using cross-country data on exits and VC investments in Canada, the US, Europe and several Asian countries, Brander et al. (2015) investigated the exit performance of GVC- and PVC-backed firms, finding that companies backed by PVC or MVC had a significantly higher probability of a successful exit than companies backed exclusively by GVC. When controlling for the amount of capital invested, however, all differences disappeared. Similar results were reached by Cumming et al. (2014a) for a sample of European companies.

A few papers have used patents as a measure of innovation in VC-backed companies. The general finding is captured by Brander et al. (2010) and Bertoni and Tykova (2015): PVC-backed firms were more likely than GVC-backed firms to produce patents.

Crowding out

With an established presence of GVCs, the interplay between PVCs and GVCs leads to the question of whether GVCs are crowding out PVCs. Although the results are mixed, most studies seem to find evidence for a crowding-out effect (i.e., GVC replacing PVC) from GVC rather than a crowding-in effect (i.e., more PVC). An early study by Leleux and Surlemont (2003) investigated the interplay between GVC and PVC in a European context, finding that PVC and GVC largely developed independently from each other. However, a more recent study by Brander et al. (2015) finds evidence that the presence of GVC crowds *in* PVC. Analyzing a different sample of VC-backed firms in Canada, the US and numerous European countries, Cumming and Macintosh (2006) and Armour and Cumming (2006) instead find evidence that GVC was crowding out PVC. Cozzarin et al. (2015) find that GVCs crowded out PVC in the home market and that, in response, PVC investors chose to reallocate its investments to neighboring countries. An interpretation of these mixed results could be that the risk for crowding out PVC depends on how GVC is carried out, and/or on the context in which it is done. For example, if GVC competes with PVC for investments, and offers investment terms that PVC cannot compete with (e.g. more lenient contracts, higher share prices), then there is clearly a risk that entrepreneurs will opt for GVC even though PVC is available. However, if GVCs avoid competition with PVC, then the risk of crowding out may be reduced.

4. Data and description

Data on VC stem from two sources. Data on private equity investments is provided by the Swedish Venture Capital Association (SVCA). On behalf of its European parent organization, Invest Europe (formerly EVCA), SVCA asks its members to submit information about all their investments; each observation in the dataset represents one transaction from an investor to a receiving company. Data on governmental VC investments is provided by the Swedish Agency for Growth Policy Analysis. The VC datasets include information on approximately 700 Swedish entrepreneurial firms that received VC during 2007-2013. The SVCA database includes all forms of *private equity* investment, including buyouts and growth capital. In this paper we focus on private equity invested in the early stages, i.e., *venture capital*. Following Invest Europe's classification of investment stages, VC investment was defined to include the categories "seed", "start-up” and “later-stage venture”, but not “growth capital” (see definitions below). GVC is defined as the six VC firms wholly funded and operated by the government that we observe in our sample, and does not include quasi-governmental VCs[6]. The data do not include private equity investments made by private individuals, so-called *business angels* (sometimes referred to as “informal venture capital”).

Table 1. Definitions of venture capital investment stages.

Seed	Financing provided to research, assess and develop an initial concept before a business has reached the start-up phase.
Start-up	Financing provided to companies for product development and initial marketing. Companies may be in the process of being set up or may have been in business for a short time, but have not sold their product commercially.
Later-stage financing	Financing provided for the expansion of an operating company, which may or may not be breaking even or trading profitably. Later-stage venture tends to finance companies already backed by venture capital firms.

Source: Invest Europe (2016)

Yearly data on firms’ input and output are provided by Statistics Sweden (SCB) and cover all Swedish firms. Firm-level data complement VC data with information on production, sales, employment, value added, investments, physical capital, profits, industry affiliation, educational attainment of the labor force, geographic location, etc., spanning the period 2007-2013. All firm-level datasets are merged using unique individual firm-year ID codes.

Figure 1 presents the total amounts of GVC and PVC invested in Sweden from 2007-2014. As shown in the figure, there was a sustained decline in PVC investments in Sweden starting from the global financial crisis in 2008 until 2013. During the same period, the amount of GVC investment increased substantially. In the sectoral dimension (not shown), ICT is the single biggest sector for VC, followed by life sciences; together, those sectors account for 72% of invested VC. *Energy and environment* and *business and industrial products and services* account for just under 10% each. The remaining 10% is divided between *consumer goods, services and retail*, financial services and *agriculture, chemicals and materials*.

[6] These include publicly owned pension funds such as the 6th AP Fund and VCs that are independently run but funded partially with public funds, such as the VC Stockholm Innovation and Growth (what is known as a “hybrid” public-private VC)

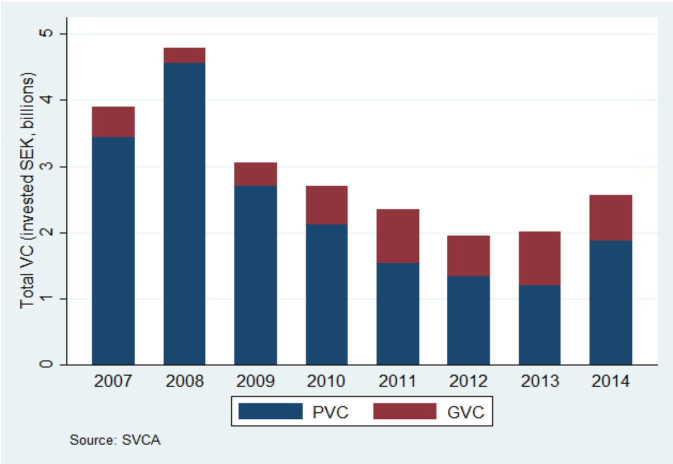

Figure 1. Total yearly VC investment in Sweden, GVC and PVC

The set of GVC investors consists of six GVCs that are wholly funded and operated by the government (what's known as "*direct* GVC"): Almi Invest, Industrifonden, Inlandsinnovation, Fouriertransform, Innovationsbron and Saminvest Mitt AB. Looking at the six governmental VC-firms there are some differences in their aim and scope. For example, while Industrifonden focuses on high-tech firms with growth potential, Inlandsinnovation focuses on firms located in the north of Sweden, Almi Invest goes for public-private co-investments in early stage ventures and Fouriertransform was created to support the struggling auto industry in the wake of the financial crisis. Its mandate was later expanded to include other manufacturing industries.

Our data include 699 companies receiving VC. As shown in Table 2, a majority of these companies (55 percent) were financed either partially or entirely by GVC.[7] Looking at the size of PVC and GVC investments, the broad pattern is that companies backed by GVC tend to receive less VC per company than companies backed by PVC (or MVC) while companies backed by GVC and PVC tend to receive slightly more VC than companies backed by PVC only.

[7]Almi Invest makes nearly all of its investments together with private investors and business angels. Further, Tillväxtanalys (2016) states that 35 percent of Almi's co-investments are made with business angels, which are not observed in our data. For this reason, the share of "GVC only" companies is likely to be overestimated somewhat.

Table 2. Companies in each category of public and/or private VC backing.

Type of VC	Number of firms	Share of firms	Total VC invested, Mkr	Avg. VC per company, Mkr
GVC only	237	34%	1200	5.1
PVC only	317	45%	9483	29.9
GVC and PVC	145	21%	6525	45.0
Total	699	100%	17209	24.6

Table 3 provides descriptive statistics of VC investments in the three investment stages: seed, start-up and later-stage. As shown in the table, the average size of the VC investment roughly doubles at each stage. One finding is that even though GVC according to theory should focus on the earliest stages of financing, total PVC and GVC investments are distributed in a similar manner with regard to investment stage. For both PVC and GVC, approximately two percent of investments went to seed funding, with private investors allocating a slightly higher seed share (2.2 percent GVC-seed vs. 2.7 percent PVC-seed). Looking at the number of investments (tranches), a similar picture emerges, with 7.7 percent of the private tranches and a slightly lower share of GVC tranches, 7.5 percent, allocated to seed funding. Looking at subsequent stages, (start-up and later-stage) the same picture remains. There is therefore no evidence that GVCs are more specialized in funding the earliest investment stages compared to private investors. Considering that one of the primary justifications for GVCs is the assumption of a PVC funding gap in the earliest stages, this finding is noteworthy.

Among firms receiving VC, most firms receive more than one tranche. In a given year, 60 percent of all firms that receive VC receive one tranche only. That is, given that a firm has received VC in a given year, 40 percent of those firms receive more than one injection. The maximum number of tranches received by a single firm in one year is ten, and over the period of observation, the maximum number of tranches received by a single firm is 47. Thus, it is common practice in the VC industry for VCs to pay out their investments in pieces ("tranches") as the entrepreneur attains predetermined goals. Furthermore, many companies receive capital from several VCs.

Table 3. Investments by investment stage, thousand SEK.

	Median	**Mean**	**Observations**
All VC			
Seed	929	1,771	325 (7.6%)
Start-up	1,349	4,073	2,612 (61.4%)
Later stage	2,989	7,720	1,315 (30.9%)
GVC			
Seed	445	737 [2,2%]	123 (7.5%)
Start-up	898	2,013 [51,4%]	1,055 (64.4%)
Later stage	1,778	4,179 [46,4%]	458 (28.0%)
PVC			
Seed	1,339	2,401 [2,7%]	202 (7.7%)
Start-up	2,221	5,469 [49,4%]	1,557 (59.5%)
Later stage	4,114	9,612 [47,8%]	857 (32.8%)

Notes: Based on figures for the entire SVCA dataset, including unmatched firms. Share of total number of observations/tranches within parenthesis (,). Share of total VC within brackets [.].

Turning to the size of the firms that receive VC, the median firm had three employees when receiving the first VC injection and 16 percent of the companies had only one employee. We may also note that no firm with more than 221 employees received seed, early-stage, or later-stage VC.[8]

In Table 4, we tabulate some key characteristics of firms receiving VC, the control group (discussed below), and the entire population of Swedish firms.

Table 4. Descriptive statistics

Variable	**VC-backed companies**	**Control group**	**All Swedish companies**
Sales (revenues)	20,119	38,428.5	17,835.4
Capital assets (K)	47,733	262,547	35,236
No. employees (L)	14.5	19.6	10.1
Share skilled labor	56.2	54.3	14.5
Gross investments	1,559	2,328	1,094
Equity/sales	73.8	371.1	10.56
Total debt	19,736	139,161	20,197.6
Gross profit/sales	-29.9	-5.9	-0.61
Value added (VA)	5,228	16,782	6,664
Return to capital (r)	-4.58	17.5	10.1
Average wage (w)	387	365	239

Note: Nominal variables are denoted in thousands of SEK.

[8] Typically, larger firms are more prone to become targets of leveraged buyouts or growth capital.

5. Matching and empirical model

As noted in section 2 previous section, VCs engage in screening activities where the target firm's profitability, growth and survival potential are analyzed. Hence, investors do not choose investment objects randomly. This in turn leads to the question of how to create a control group of similar firms. To handle this selection problem, we use Coarsened Exact Matching (CEM) to create a control group of non-VC treated firms that in all relevant aspects are as similar possible to the VC-backed firms. For recent applications of matching methods in the VC literature, see Croce et al. (2013), Cumming et al. (2014), and Grilli and Murtinu (2014).[9]

For each of the treated firms, we match on firm properties one year before the treatment, (t-1), with t being the year a firm receives VC. The matching results are presented in Table 5. Our matching is based on the following variables (for the sales and capital equations): equity/debt, employment, employment growth, profit ratio, 2-digit industry code, and the share of high-skilled workers. Accounting for profit rate and amount of equity in the company, our matching model is slightly more extensive than that used by e.g., Paglia and Harjoto (2014), who account for 2-digit industry code, annual net sales, number of employees, and state of location.[10]

The matching results are presented in Table 5, in which the first two columns report the imbalance between the treatment and control groups, and in parentheses (.), the imbalance between treated and all non-treated firms. As noted by Iacus et al. (2011, 2012), the value

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[9] Compared to the propensity score matching (PSM) technique, CEM has some useful properties (Iacus et al., 2011, 2012; Blackwell et al., 2009; King and Nielsen, 2016). Most importantly, the CEM estimator satisfies the property of *monotonic imbalance bounding*, which means that total balance can be improved by improving the balance of a single covariate. When using PSM, there is no way of knowing whether the total balance in the matching has been improved by improving the balance of a single covariate or by adding and removing additional covariates. The key difference between CEM and PSM, therefore, is that CEM allows for a systematic way of working with different matching variables to increase balance (Ho, et al., 2007, p.219). A further property of CEM that is conducive to finding a suitable control group is that it is more robust to the presence of measurement error (Blackwell et al., 2009).
additional covariates. The key difference between CEM and PSM, therefore, is that CEM allows for a systematic way of working with different matching variables to increase balance (Ho, et al., 2007, p.219). A further property of CEM that is conducive to finding a suitable control group is that it is more robust to the presence of measurement error (Blackwell et al., 2009).
[10]Because it is not advisable to match on the dependent variable, when considering the employment regression we replace employment and employment growth with sales and sales growth. We perform a 1-to-1 match that associates each VC-backed firm with one control firm.

of the imbalance test is subordinate to the change in imbalance as given by matching. As shown in Table 5, matching reduces the imbalance for all variables, suggesting that matching leads to a control group that is more similar to the treatment group than the collection of all non-treated firms. In columns 3-5, we present average values for the matching variables for the three groups: all firms, the control group and the treatment group. Again, we see that for all of the variables but employment and sales, the absolute difference in averages between the treated firms and non-treated firms is smaller for the control group than for all non-treated firms. Finally, the bottom row reports the overall imbalance between the treatment and control groups.

Table 5. Matching results.

	Matching imbalance		**Mean values**		
	Sales equation	Employment equation	Mean (treated)	Mean [(A)] (controls)	Mean (all firms)
Employment	0.09 (0.32)		14.50	19.64	10.14
Employment growth	0.09 (0.44)		0.12	0.04	0.01
Profit ratio	0.04 (0.72)	0.03 (0.72)	-29.86	-4.94	-0.61
Skill share	0.04 (0.69)	0.00 (0.69)	56.22	54.29	14.46
Sni-2 (industry code)	0.05 (0.67)	0.04 (0.67)	57.03	56.27	53.21
(Equity/debt)	0.15 (0.20)	0.14 (0.20)	3.51	2.54	.2.46
Sales		0.03 (0.12)	20,119	38,428	17,835
Sales growth		0.09 (0.44)	0.20	0.03	-0.01
Overall L1 dist.	0.55	0.58			

Note: Matching imbalance, univariate L1 distance between treated and control group, imbalance between treated and all other firms within parenthesis (.).
[(A)]Control group averages from the sales equation matching.

Our econometric analysis investigates the impact of VC on sales, employment and physical capital. For the analysis of the direct impact of VC on sales, we build on Liu and Yoon (2000), Griliches and Mairesse, (1997) and Frankel and Romer (1999) and estimate an augmented production function model. The estimated model is formulated as follows:

$$\ln Y_{it} = \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \sum_{h}^{H} \beta_{3h} H_{hit} + \beta_4 \ln debt_{it} + \beta_5 equity_{it} + \beta_6 \pi_{it} + \sum_{t+s}^{T} \beta_{7s} VC_{it+s} + \beta_8 T_i + v_i + \gamma_t + \varepsilon_{it} \quad (1)$$

where Y_{it} is sales in firm *i* at time *t*, *L* is the number of employees, *K* is the capital stock, *H* is the shares of the labor force with secondary, short tertiary and longer tertiary education, *Debt* is total debt, *equity* is the equity ratio equity/sales, π is the profit ratio, *T* is a balancing indicator taking the value of one for all years for treated firms and zero for non-treated firms, v_i represents firm-fixed effects, γ_t is a period dummy and ε_{it} is the error term. The term $\sum_{t+s}^{T} VC_{it+s}$ refers to a set of dummy variables that capture the instantaneous (s=0) and post-treatment effects (s=1,…,T) of VC on firm sales. Using a matched control group, this model represents a standard conditional matched difference-in-differences (DiD) model. In the analysis, the model will be elaborated to consider impact lags, endogeneity, and indirect effects.

As shown in equation 1, sales are a function of capital and labor (K, L). These variables can also be affected by a VC injection. We therefore complement equation (1) with estimations of the impact of VC on employment and capital, which comprise factor demand. When estimating the impact of VC on factor demand (K and L), we draw on the labor demand literature in which labor and capital are both considered factors of production. Demand for these factors (K and L) can be derived from the cost function, $C_i(w_i, r_i, y_i)$,which is a function of factor prices, i.e., wages (w), the interest rate (*r*) and output (*y*). Following the common assumption of adjustment costs suggests the inclusion of the lagged dependent variable on the right-hand side of the equation, yielding the following general expression for factor demand (Cahuc and Cylberg, 2004; Hijzen and Swaim, 2008).

$$\begin{aligned} \ln V_{F_{it}} = \; & \alpha_i + \beta_v \ln V_{F_{it-1}} + \beta_r \ln r_{it} + \beta_w \ln w_{it} + \beta_y \ln Y_{it} + \sum\nolimits_h^H \beta_{3h} H_{hit} \\ & + B_4 \ln debt_{it} + \beta_5 equity_{it} + B_6 \pi_{it} + \sum\nolimits_{t+s}^{T} \beta_{7s} VC_{it+s} + B_8 T_i + v_i \\ & + \gamma_t + \varepsilon_{it} \end{aligned} \qquad (2)$$

Where $F = \{L, K\}$. In equation (2), we present the full factor demand model fitted with treatment variables and augmented with additional control variables. The inclusion of a lagged dependent variable imposes an endogeneity problem. To manage this problem, we apply the Han and Philips (2010) dynamic panel data estimator. The estimator relies on (long) differencing and is not burdened by the problem of (weak) moment conditions. As shown by Han and Philips (2010) the differencing approach has good short panel properties.

VC does not only have a direct impact on sales but may also feed into sales through investment (capital stock) and employment. For these reasons, when analyzing the impact of VC on sales, results from the production function based model might not fully capture the impact of VC on sales. We therefore combine the factor demand equations (2) for capital and employment with the sales equation in a structural equation system. Combining these equations into a structural equation system allows us to analyze both the direct impact of VC on sales and the total impact of VC, where indirect effects, transmitted through changes in employment and the capital stock, are included. The structure of the system is depicted in Figure 2.

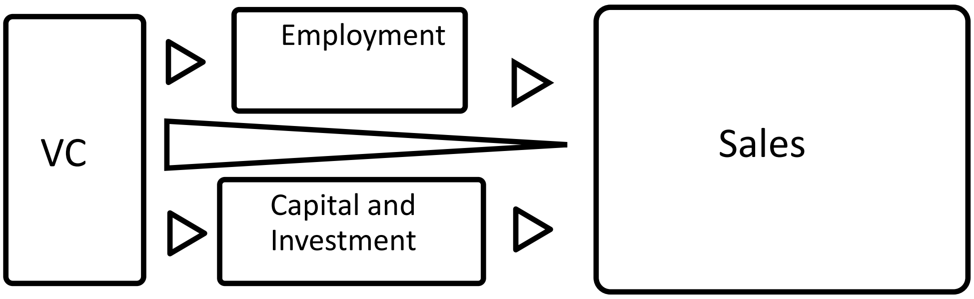

Figure 2. Direct and indirect effects of VC on sales

Ass seen in the estimations below, the estimated structural equation system is based on a simplified version of factor demand in which we assume no adjustment costs and replace firm-fixed effects with two-digit industry dummies. For details on structural equation models (SEM), see (Acock, 2013; Kline, 2010; Matsueda, 2012). In addition to using a matched control group, we will analyze the impact of VC using fixed-effect estimations of the treatment group only (treatment on the treated). This strategy seeks to identify trend-breaks instead of comparing the development of two groups of firms (Heyman et al., 2006; Tillväxtanalys, 2014, 2015).

6. Results

We develop the analysis of how VC impacts sales, employment and physical capital stock in several steps. Beginning with the *direct* effect of VC investments, we use a standard fixed effect panel data estimator to analyze the treatment effect by way of both DiD- and treatment on the treated analysis. Next, we turn to a structural equation system to analyze the *total* effect of VC on sales where we allow for indirect effects that work through employment and investment in physical capital. Finally, we take a closer look at the impact of VC investments on the sub-channels, employment and capital, respectively. In each of the steps, we present separate results for firms that receive PVC only, GVC only, and firms that receive both PVC and GVC, referred to as mixed VC (MVC). In the analysis, we follow the impact of VC (the treatment effect) over time both from the time it "arrives" $(t = 0)$ at the company and for the t$= 1, \ldots, 4$ years after receiving the VC investment.[11]

6.1. The direct effect of venture capital on firm sales

We begin the analysis to see how the three types of VC investment directly impact firm sales. Table 6 shows the results when we restrict the sample to only include firms that received VC investment at some time during the period. The results are estimated using fixed effects at the firm level. The analysis therefore traces trend breaks in firm sales when and after receiving VC. Starting with firms receiving PVC only (column 1), there is no evidence of increased sales after receiving PVC. Instead, we detect a negative impact on sales the same year that VC is received. One possible explanation for the immediate drop in sales is increased investments, which we will investigate in section 6.3. The contemporary drop is in line with the J curve hypothesis discussed by Meyer and Mathonet (2011). Moving on to firms receiving GVC only, we find a somewhat different pattern. We do not see a dip in sales at the time of the VC investment, and there is a tendency toward positive post-treatment effects on sales. Specifically, we find in periods (t+1), (t+2) and (t+4), there is evidence of a significant positive impact on sales with the largest coefficient of 0.42 suggesting a sales increase of 52 percent, four years after receiving GVC.[12] Thus, in the years after receiving GVC, sales seem to take off. Approximately 20 percent of the firms in our sample receive both public and private VC. According to e.g., Brander et al,

[11]Due to sample size issues in the post-treatment period, we limit the analysis to a maximum of four years after the firm received VC.

[12] $(e^{0.42} - 1)*100 = 0.52$

(2015), Bertoni and Tykova, (2015) and Grilli and Murtinu, (2014), firms that receive both GVC and PVC tend to perform about as well as firms receiving PVC only and better than firms receiving GVC only. This could be attributable to the advantages of being backed by a more diverse group of investors (Colombo et al, 2014), or receiving a greater amount of VC (Brander et al, 2015).

Table 6. Dependent variable, firm sales. Fixed effect models, treated firms only

	1. PVC	**2.GVC**	**3. Mixed VC**	**4. Service sector** [(A)]	**5. Manu. sector** [(A)]
***ln*(K)**	0.1904 (0.062)***	0.0972 (0.074)	0.0918 (0.076)	0.1645 (0.047)***	0.0022 (0.065)
***ln*(L)**	0.5998 (0.080)***	0.6618 (0.074)***	0.4797 (0.078)***	0.5540 (0.058)***	0.8176 (0.088)***
Md-skill	7.6e-05 (0.003)	-0.0052 (0.003)*	0.0080 (0.007)	5.8e-05 (0.003)	0.0037 (0.004)
Hi-skill short	-0.0052 (0.003)	-0.0069 (0.003)**	0.0045 (0.008)	-0.0057 (0.003)	0.0024 (0.005)
Hi-skill long	-0.0033 (0.003)	-0.0083 (0.003)***	.00323 (0.007)	-0.0037 (0.003)	0.0013 (0.005)
***ln*(Tot. debt)**	0.2794 (0.056)***	0.2015 (0.069)***	0.3595 (0.063)***	0.2707 (0.044)***	0.3447 (0.047)***
Equity/sales	1.3e-05 (0.0001)	0.0004 (0.0004)	0.0009 (0.0002)***	1.6e-05 (0.0002)	0.0010 (0.0002)***
Profit/sales	0.0012 (0.0001)***	0.0060 (0.002)***	0.0031 (0.0006)***	0.0014 (0.0003)***	0.0034 (0.0007)***
Period dummies	yes	yes	yes	yes	yes
Firm dummies	yes	yes	yes	yes	yes
VC (t)	-0.1909 (0.094)**	-0.0605 (0.085)	-0.1141 (0.131)	-0.1551 (0.063)**	-0.0616 (0.097)
VC (t+1)	-0.0078 (0.116)	0.1988 (0.113)*	-0.0201 (0.151)	0.0484 (0.079)	0.0899 (0.108)
VC (t+2)	-0.0612 (0.1349)	0.2911 (0.152)*	0.0729 (0.154)	0.1445 (0.092)	0.0417 (0.143)
VC (t+3)	-0.0236 (0.161)	0.2900 (0.177)	0.2003 (0.160)	0.2013 (0.114)*	0.2410 (0.167)
VC (t+4)	-0.0247 (0.197)	0.4204 (0.210)**	0.3476 (0.204)*	0.3030 (0.147)**	0.1431 (0.227)
R^2-within	0.51	0.52	0.50	0.46	0.59
Obs.	1,945	1,124	945	3,173	841

Note: *, **,and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors clustered at the firm level.

[(A)] For the manufacturing and service sectors, the analysis covers all types of VC.

However, the results in column 3 of Table 7 do not suggest any significant effects of mixed VC on firm sales except in (t+4). In other words, four years after the VC investment, there is a tendency for MVC-backed firms to grow faster than they would have had they not received VC. Finally, in columns 4-5 in Table 6 we separate manufacturing sector firms from service sector firms and analyze the evolution of sales after receiving VC.

Starting with the manufacturing sector, the results suggest no significant effects of VC on firm sales either in the same year as or after receiving VC. For the service sector, however, we find an initial dip in sales the same year as the VC investment is made; this dip is followed by a positive post-treatment effect that becomes significant three-four years after the capital injection. As shown in Table 6, the post-treatment effect peaks four years after receiving capital with an estimated sales increase of 35 percent.[13] Thus, for many firms, and in line with the J-curve hypothesis, the positive effect of VC on sales comes with a delay. Moving on to the control variables, capital and labor appear with positive and significant signs. Firms' labor composition is captured by three skill-intensity variables measuring the share of labor in each group, taking the share of low-skilled labor (primary education) as a reference. The general impression throughout the analysis is that the skill composition is uncorrelated with firm sales.

VC is one of many sources of funding for investments and the need for VC is therefore related to the firm's financial strength. It is therefore interesting to analyze other measures of financial capacity such as equity, debt and profits. The results in Table 6 suggest that there is little evidence of a systematic relation between sales and equity per sales. Looking at the elasticity of debt with respect to sales, the estimated elasticity is smaller than one, suggesting that in relation to sales, the relative size of total debt decreases as firms grow larger, i.e., a relatively low debt ratio among larger firms that receive VC.

The analysis in Table 6 involves identifying trend breaks. One complication of this analysis is that the treatment effects hinge on variation over time and within firms during the period of treatment. We therefore proceed in Table 7 by introducing CEM-matched "twin" firms that did not receive VC.[14] Special attention is paid to analyzing whether firms receiving GVC evolve differently from those receiving PVC. Therefore, in column 4 we

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[13] $(e^{0.32} -1)*100 = 0.35$.

[14] To ease the comparison across different treatment groups, treated firms are compared against the same reference group.

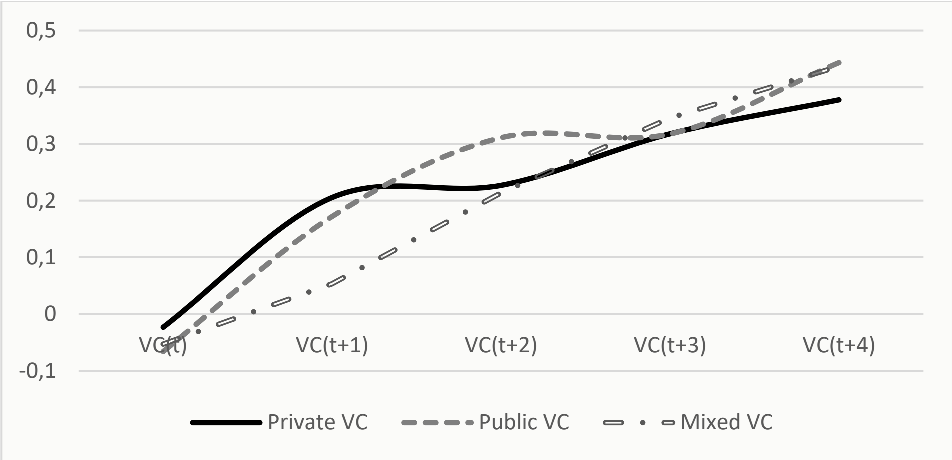
use firms receiving PVC only or GVC only. Merging these groups into the same model allows us to directly analyze how the impact of GVC differs from that of PVC.

Table 7. Dependent variable, firm sales. FE-estimations. Matched control firms included.

	1. PVC	**2. GVC**	**3. Mixed VC**	**4. PVC vs. GVC.** (A)	
	Estimation 1-3. CEM-matched data			PVC	GVC
VC (t)	-0.0232 (0.062)	-0.0660 (0.072)	-0.0529 (0.117)	-0.1261 (0.072)*	0.2117 (0.081)***
VC (t+1)	0.2056 (0.073)***	0.1721 (0.081)**	0.0534 (0.137)	0.0921 (0.089)	-0.0386 (0.104)
VC (t+2)	0.2270 (0.074)***	0.3110 (0.117)***	0.2138 (0.122)*	0.0803 (0.100)	0.065 (0.146)
VC (t+3)	0.3179 (0.088)***	0.3176 (0.142)**	0.3455 (0.143)**	0.1537 (0.123)	-0.0086 (0.211)
VC (t+4)	0.3778 (0.115)***	0.4434 (0.147)***	0.4369 (0.153)***	0.1891 (0.158)	0.1163 (0.180)
Full set of controls	yes	yes	yes	yes	
R^2-within	0.40	0.48	0.41	0.49	
Obs.	8,761	7,933	7,754	3,069	

Notes: *, **,and *** indicate significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors clustered at the firm level. For control variables, see Table 7. (A) Estimations in column 4 are based on firms receiving GVC only and firms receiving PVC only.

Introducing a control group strengthens the tendencies observed in Table 6. First, using a matched sample of treated firms we see in Table 7 that sales do not take off in the same year that VC is received. Moving to the post-treatment period, we note in columns 1-3 that sales among firms receiving (any form of) VC grow faster than sales among the control group of firms not receiving VC. The growth pattern for firms receiving different types of VC is depicted in Figure 3 below.



Note: Figure is based on results in Table 7 columns 1-3.

Figure 3. Sales development. Firms receiving VC vs. control firms not receiving VC.

As shown in Figure 3, sales grow faster for VC-receiving firms than for the non-VC-receiving control group. Among firms receiving VC, there are some minor differences. First, although firms receiving only private or public VC have a quicker take-off compared to MVC-backed firms, after three years, they all (PVC-, GVC- and MVC-backed firms) grow at roughly the same rate. Thus, from Figure 3 it is difficult to say that one type of VC outperforms another type of VC. In other words, in most cases there are no significant differences in how different types of VC impact sales, although the timing of the growth pattern is somewhat different depending on who made the VC investment. In column 4, we change the comparison group and directly compare firms receiving private VC with firms receiving GVC. As indicated by Figure 3, there are no large differences between these groups. Specifically, for the post-treatment period there is no evidence of a significant difference between these two groups, whereas during the year of receiving VC, there is a tendency of more rapid growth in sales among firms receiving GVC compared to those receiving PVC.

6.2. Including indirect effects of venture capital on firm sales

Estimates of the impact of VC on firms' sales might be misleading if VC impacts sales not only directly but also indirectly through investment and employment. To address this issue, we estimate a structural equation system (SEM) from which the direct and indirect effects of VC can be disentangled.[15] To ease the presentation, the treatment effects are summarized below in Table 8 and further depicted in Figure 4. The table presents the direct and total effects. In the case that the direct effect differs from the total effect, we can attribute the change to the indirect effect of VC that goes through changes in employment and investments in physical capital.

Starting with the significance of the total effect of VC, we note in Table 8 that there are no significant treatment effects for MVC, whereas firms backed by PVC show a positive treatment effect in both the treatment year and all post-treatment periods. GVC takes an intermediate position with a significant total effect both in the treatment year and four years after the VC injection.

Table 8. Structural equation estimations of the direct and total effects of VC on firm sales.

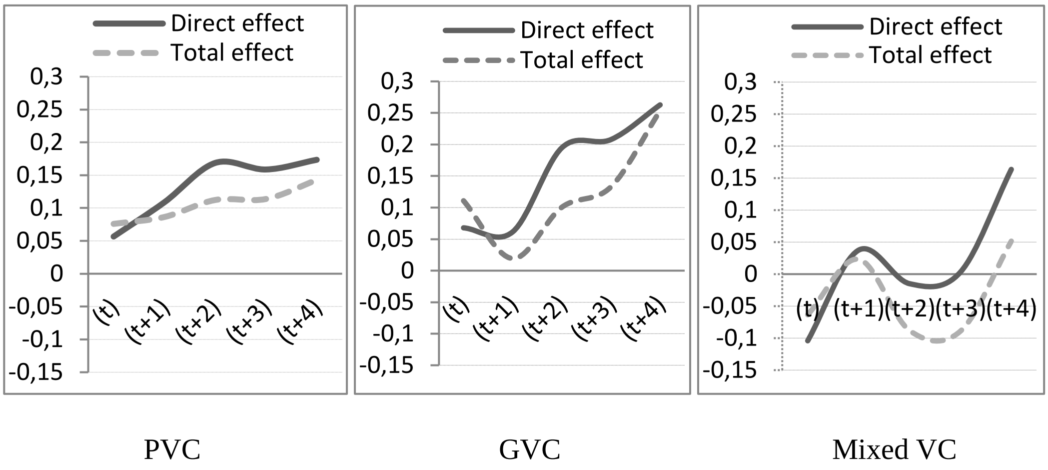
	PVC		**GVC**		**MVC**	
	Direct effect	*Total effect*	*Direct effect*	*Total effect*	*Direct effect*	*Total effect*
VC (t)	0.0566 (0.048)	0.0759 (0.044)*	0.0679 (0.046)	0.1108 (0.043)***	-0.10413 (0.066)	-0.0635 (0.061)
VC (t+1)	0.1088 (0.046)**	0.0864 (0.042)**	0.0615 (0.060)	0.0192 (0.060)	0.0374 (0.078)	0.0233 (0.077)
VC (t+2)	0.1687 (0.057)***	0.1123 (0.057)**	0.1948 (0.099)**	0.1005 (0.087)	-0.0149 (0.124)	-0.0880 (0.116)
VC (t+3)	0.1587 (0.062)***	0.1138 (0.057)**	0.2078 (0.105)**	0.1329 (0.092)	0.0031 (0.110)	-0.0891 (0.093)
VC (t+4)	0.1735 (0.089)*	0.1427 (0.080)*	0.2628 (0.165)	0.2536 (0.127)**	0.1636 (0.113)	0.0515 (0.089)
Full set of controls	yes		yes		yes	
Obs.	6,415		6,171		2,341	

Note: For control variables see Table 6. Firm fixed effects are replaced with industry dummies at the 2-digit level. Estimation of treated vs. control group.

Comparing the total and direct effects of VC, in Figure 4 we see that the direct effect of VC typically is larger than the total effect for all years but the treatment year. This result holds for all types of VC: private, public and mixed. One might argue that the low total effect is attributable to missed dynamics in the estimates of Table 4, in which the post-treatment effect is analyzed period-by-period. In other words, if investment and employment effects differ in their dynamic patterns, then the results can be misleading. As

[15]Full set of estimations available on request.

a robustness test and to increase the comparability of the direct and total effects of VC, we therefore proceed with a simplified dynamic analysis in which we replace the period dummies with a treatment dummy (*treat*) covering the treatment year and all post-treatment years. Therefore, the treatment dummy signals the average effect of VC over all observed treatment and post-treatment years. The average treatment effect is displayed in Table 9, in which estimations are based on the same model as those in Table 8.



Note: Based on estimates from Table 8. Total effects of VC: Private VC significantly different from zero at (t), (t+1), (t+2), (t+4); Public VC at (t), (t+4); Mixed VC not significantly different from zero in any period.

Figure 4. Direct and indirect effects of VC on sales. Treated vs. matched control group (SEM estimations).

Table 9 confirms the dynamic patterns detected in Figure 4 and Table 8 and can be summarized in three bullet points: (i) The impact of PVC seems to be larger than that of GVC (but not significantly larger); (ii) There is little evidence of a significant effect of MVC on sales; and (iii) When evaluating the over-all-periods effect, the average direct effect of VC on sales is larger than the total effect.

The absence of positive indirect effects leads to the question of how VC impacts investments and labor demand. We therefore continue by taking a closer look at the relationships between VC, labor demand and investments.

Table 9. Robustness test. Dependent variable, firm sales. SEM-system, matched firms.

Group of comparison	**Variable**	**Direct effect**		**Total effect**	
Estimation 1. PVC	VC treatment incl. post treat	0.1115 (0.036)***		0.0900 (0.033)***	
Estimation 2. GVC	VC treatment incl. post treat	0.0999 (0.040)**		0.0873 (0.037)**	
Estimation 3.MVC	VC treatment incl. post treat	-0.0366 (0.059)		-0.0399 (0.053)	
		Direct effect		Total effect	
		Private VC	Public VC	Private VC	Public VC
Estimation 4. PVC vs. GVC	VC treatment incl. post treat	0.0532 (0.040)	0.0245 (0.043)	0.0874 (0.039)**	0.0438 (0.039)

Note: *, **,and *** indicate significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors. For control variables, see Table 6.
Estimation 1, PVC-backed firms vs. non-treated matched control group.
Estimation 2, GVC-backed firms vs. non-treated matched control group.
Estimation 3, MVC-backed firms vs. non-treated matched control group.
Estimation 4, private VC-backed firms vs. public VC-backed firms.

6.3. Effects of VC on the capital stock

In Table 10 we analyze the impact of the different types of VC on investment and the capital stock. Following Hall et al. (2001), we apply a dynamic model specification. The regressions analyzed in Table 10 are performed using the Han-Philips Fixed Effects Dynamic Panel Data estimator.[16] In line with subsequent labor demand estimations, the estimated model is based on a standard labor demand model (or more generally, demand for factors of production) with adjustment costs (Cahuc and Zylberberg, 2004; Hijzen and Swaim, 2008).

The results in Table 10 suggest that when significant, VC typically has a positive impact on investment either at the year of the VC injection or one-two years after VC has been received. After three years, no significant investment effect remains. We may also note that it is difficult to say that one type of VC outperforms other types of VC. If anything, this could indicate that all VC investors have similar target functions (making sure the firm can make needed investments). In column 4, we directly compare GVC against PVC. The results in column 4 verify the observation that it is difficult to say that one type of VC outperforms the other.

[16]See Han, et al. (2014).

Table 10. Dep.Var., ln(capital stock). Han-Philips Dynamic Panel Data estimations.

	1. Private VC	2. Public VC	3. Mixed VC	4. Private vs. Public VC [(A)]	
	Estimation 1-3. CEM-matched data				
***ln*(K)(t-1)**	0.6373 (0.059)***	0.6452 (0.064)***	0.6469 (0.065)***	0.6499 (0.057)***	
***ln*(VA)**	0.0544 (0.32)*	0.0196 (0.034)	0.0519 (0.033)	0.0320 (0.029)	
***ln*(w)**	0.0343 (0.048)	0.0192 (0.053)	0.0273 (0.053)	0.0140 (0.045)	
***ln*(r)**	0.0441 (0.063)	0.0520 (0.067)	0.0694 (0.068)	0.0417 (0.059)	
Md-skill	0.0041 (0.002)*	0.0022 (0.002)	0.0028 (0.002)	0.0032 (0.002)	
Hi-skill short	0.0065 (0.003)***	0.0035 (0.003)	0.0040 (0.003)	0.0055 (0.002)**	
Hi-skill long	0.0038 (0.002)	0.0016 (0.002)	0.0011 (0.002)	0.0037 (0.002)*	
ln(tot.Debt)	0.3438 (0.027)***	0.3563 (0.027)***	0.3481 (0.027)***	0.3526 (0.025)***	
Equity/sales	0.0034 (0.002)**	0.0026 (0.002)*	0.0027 (0.002)*	0.0037 (0.001)**	
Profit/sales	-0.1231 (0.050)**	-0.1006 (0.051)**	-0.1020 (0.50)**	-0.1332 (0.048)***	
Period dum.	yes	yes	yes	yes	
Firm dum.	yes	yes	yes	yes	
				Private	Public
VC (t)	0.1737 (0.120)	0.2737 (0.138)**	0.3206 (0.165)*	0.1612 (0.120)	0.2661 (0.139)*
VC (t+1)	0.2825 (0.155)*	0.2588 (0.194)	0.4754 (0.204)**	0.2667 (0.155)*	0.2471 (0.195)
VC (t+2)	0.3295 (0.187)*	0.1527 (0.268)	0.4707 (0.260)*	0.2969 (0.188)	0.1432 (0.270)
VC (t+3)	0.3072 (0.229)	0.3217 (0.389)	0.3481 (0.350)	0.2668 (0.230)	0.3182 (0.392)
VC (t+4)	-0.1078 (0.267)	0.7455 (0.556)	0.5938 (0.522)	-0.1538 (0.269)	0.7290 (0.560)
R^2	0.0610	0.0602	0.0618	0.0625	

Notes: *, **,and *** indicate significance at the 10, 5, and 1 percent levels, respectively.
[(A)] Estimations in column 4 are based on firms receiving public VC only and firms receiving private VC only. In column 4, we therefore directly compare firms receiving private VC only with firms receiving public VC only.

Turning to the control variables, we see that investments are positively related both to debt and to equity, suggesting that investments are partially financed by loans and own capital. The results suggest that profits go down when investments are made. Considering that the implementation of a new investment can lead to a reallocation of resources from directly productive activities to investment activities, these results may be expected. Looking at the skill composition, on average we find little evidence for a systematic relation between firm skill composition and investments. Moving to factor prices, we find, as expected, a positive relation between investments and labor cost, whereas the positive relation with return on capital is less expected. Finally, we note a positive relation between capital and value added along with evidence of persistence in investment patterns.

To test the robustness of the investment analysis, in Table 11 we re-estimate the investment regression from Table 10 using a fixed-effects (FE) model with no transition dynamics.

Using an FE-model, the overall sizes and significance of the estimates increase and the pattern for the first three treatment periods remains similar. That is, using a fixed-effect model, we have significant investment effects for all types of investors (PVC, GVC and MVC) both during the treatment year and for the two subsequent years. Again, for the first three years, the patterns look similar for all three types of VC investments and in the last two periods they split up; however, so does the variance and uncertainty of the estimates.

Combining results from Tables 10 and 11, we conclude that the sizes of the investment results are not fully stable with respect to choice of model and estimator, but there is a clear tendency toward a positive and significant (physical capital) investment effect from VC at the treatment year and during the two subsequent years. After three-four years, the investment effect seems to wear off or becomes less significant. Finally, there is no strong evidence for one type of VC (PVC, GVC or MVC) giving rise to larger and more significant capital investments than the others. Considering that financing investments is one of the most common motivations behind raising VC, the finding of a positive investment effect is not surprising.

Table 11. Dependent variable, *ln*(K). Fixed-effect estimations.

	1. Private VC	2. Public VC	3. Mixed VC	4. Private vs. Public VC [(A)]	
	Estimation 1-3. CEM-matched data			PVC and GVC firms	
				PVC	GVC
VC (t)	0.6462 (0.120)***	0.6866 (0.141)***	0.7758 (0.146)***	0.6277 (0.119)***	0.6671 (0.141)***
VC (t+1)	0.6954 (0.126)***	0.7196 (0.144)***	0.8698 (0.180)***	0.6672 (0.127)***	0.6813 (0.142)***
VC (t+2)	0.6904 (0.131)***	0.3702 (0.206)*	0.7211 (0.030) **	0.6547 (0.130)***	0.3367 (0.205)*
VC (t+3)	0.5528 (0.177)***	0.4263 (0.257)*	0.4340 (0.389)	0.5137 (0.177)**	0.3875 (0.256)
VC (t+4)	0.2656 (0.222)	0.4140 (0.361)	1.5366 (0.224)***	0.2277 (0.222)	0.3409 (0.360)
All controls.	yes	yes	yes	yes	
R^2	0.5038	0.4944	0.5010	0.5031	

Notes: Robust standard errors clustered at the firm level. For control variables, see Table 10. No lagged dependent variable used. [(A)] Estimations in column 4 are based on firms receiving public VC only and firms receiving private VC only.

6.4. The impact of VC on Employment

From a policy perspective, increased employment is a desired effect of GVC investments. In addition, employment is, together with physical capital, a channel for the indirect effects of VC on sales.[17] The results from the employment regressions in Table 12 can be summarized as there being no significant effects of VC on employment within four years after receiving the investment. The only exception is for mixed VC, for which we have a positive employment effect at the treatment year and a negative employment effect two years after the VC injection. Considering both that these results go in opposite directions and the overall lack of significant effects, the results suggests that VC does not primarily boost employment in the short term. One possible interpretation of this result is that young VC-backed firms are in the early stages of R&D and have yet to reach scalability in their production, which is supported by e.g. Puri & Zarutskie (2012) who find evidence of strong growth effects in the long term. In addition, most point estimates suggest a tendency toward a negative employment effect. These results lead to two conclusions.

[17] The employment regressions analyzed in Table 11 are performed using the Han-Philips Fixed Effects Dynamic Panel Data estimator. The estimated model is based on a standard labor demand model with adjustment costs (Cahuc and Zylberberg, 2004; Hijzen and Swaim, 2008).

First, as noted in Tables 8-9, there is a tendency for the total effect of VC on firms' sales to be lower than the direct effect, suggesting a negative indirect effect of VC working through investment and employment. It is therefore likely that the generally lower total effect of VC (compared to the direct effect) can be explained by a drift toward negative employment effects. Second, the drift toward a positive investment effect of VC and a non-positive employment effect suggests that VC can be considered a trigger for increased efficiency, where capital investments are made at the same time as employment is held back. This would seem to be consistent of previous studies that found that VC increased efficiency in target firms (Chemmanur et al., 2011; Croce et al., 2013; Alperovych et al. 2015), although further investigation is warranted. For private investors, the lack of a positive employment effect from private VC is unproblematic. The primary goal of private investors is return on investment, something that can be achieved without employment growth. For GVC, however, employment is often a desired outcome, which can cause a conflict of interest when public investors want to achieve both increased competitiveness and employment, or when they co-invest with PVC.[18] Our findings of negligible employment growth and delayed sales growth following VC investment are consistent with those of Grilli and Murtinu (2014), although they do not find significant sales growth among GVC-backed firms.

[18] As a robustness test, employment regressions are estimated using both the Arellano and Bond (1991) estimator and the Blundell and Bond (1998) system GMM estimator with similar results. Results available on request.

Table 12. Dependent variable, log of employment. Han-Philips Dynamic Panel Data estimations.

	1. Private VC	2. Public VC	3. Mixed VC	4. Private vs. Public VC (A)	
	Estimation 1-3. CEM-matched data				
***ln*(L)(t-1)**	0.7423 0.046)***	0.6643 (0.047)***	0.6489 (0.048)***	0.9181 (0.083)***	
***ln*(VA)**	0.5827 (0.011)***	0.6316 (0.011)***	0.6200 (0.011)***	0.7143 (0.026)***	
***ln*(w)**	-0.5135 (0.012)***	-0.5556 (0.013)***	-0.5381 (0.013)***	-0.6141 (0.031)***	
***ln*(r)**	-0.0480 (0.003)***	-0.0503 (0.003)***	-0.0524 (0.003)***	-0.0550 (0.008)***	
md-skill	-0.0003 (0.0005)	-0.0004 (0.0005)	-0.0002 (0.0005)	-0.0006 (0.002)	
Hi-skill short	-0.0009 (0.0006)	-0.0010 (0.0006)*	-0.0010 (0.0006)*	-0.0020 (0.002)	
Hi-skill long	-0.0009 (0.0005)*	-0.0010 (0.0005)*	-0.0011 (0.0005)*	-0.0025 (0.002)	
Profit/sales	-0.0169 (0.004)***	-0.0166 (0.004)***	-0.0154 (0.004)***	-0.2972 (0.038)***	
Period dummies	yes	yes	yes	yes	
Industry dummies	yes	yes	yes	yes	
				Private	Public
VC (t)	-0.0092 (0.034)	0.0541 (0.037)	0.1034 (0.058)*	-0.0095 (0.042)	0.0403 (0.045)
VC (t+1)	-0.0291 (0.046)	-0.0127 (0.052)	0.0766 (0.071)	-0.0346 (0.058)	-0.0275 (0.066)
VC (t+2)	0.0035 (0.055)	-0.0940 (0.073)	-0.1504 (0.080)*	-0.0006 (0.077)	-0.1122 (0.098)
VC (t+3)	-0.0092 (0.066)	-0.0081 (0.089)	-0.1336 (0.094)	-0.0133 (0.104)	-0.0289 (0.128)
VC (t+4)	-0.0228 (0.078)	0.0175 (0.113)	-0.0902 (0.129)	-0.0083 (0.136)	-0.0048 (0.164)
Buse R^2	0.43	0.47	0.45	0.50	
Obs.	5,080	4,851	4,659	1,177	

Notes: Notes: *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively.
(A) Estimations in column 4 are based on firms receiving public or private VC only.

7. Robustness

7.1. The impact of VC by stage

Small, young and innovation-driven firms can find it difficult to raise capital in early stages, therefore GVCs are often motivated as a bridge filling the seed and early-stage capital gap for such firms. If GVC is biased toward seed- and early-stage financing it might be inappropriate to directly compare the performance of PVC with GVC. We therefore proceed and compare the effects of GVC and PVC at the same investment stage. The stages analyzed are: (i) seed, (ii) start-up, and (iii) later-stage investments. Over time, some firms will receive seed capital and subsequently receive VC for later stages. Accordingly, in subsequent years, firms are allowed to receive VC designed for later stages. In other words, in the stage classification, firms are allowed to move upward from their starting point.

Table 13 displays results by investment stage for different types of VC. The results in Table 13 reflect the treatment effect over the treatment year and all observed post-treatment years. The results can be summarized in five points: (i) We note no significant VC effects on sales for firms that receive both private and public VC (MVC-backed firms). The non-significance of mixed VC holds for all investment stages. (ii) GVC is the only type of VC for which we find a positive effect of seed capital on sales. (iii) PVC outperforms other types of VC in start-up stage financing. (iv) For later-stage financing, we note a positive estimate for GVC, although this (positive) result only holds when including indirect effects. (v) For seed and start-up financing, the total effect of VC is lower than the direct effect. Thus, considering the investment stage does not alter earlier results suggesting an overall negative indirect (combined capital and employment) effect on sales.[19]

[19] Results in Table 12 are taken from the SEM-estimation with a simplified labour demand specification assuming no adjustment costs in labour and capital. For control variables, see Table 5.

Table 13. SEM DiD-estimations, by investment stage. Dependent variable, firm sales.

	Direct effect			Total effect		
	Private VC	Public VC	Mixed VC	Private. VC	Public VC	Mixed VC
Seed capital	0.1953 (0.121)	1.3399 (0.216)***	0.1060 (0.111)	0.1258 (0.101)	0.0837 (0.173)	0.0467 (0.056)
Early stage	0.3249 (0.057)***	0.0832 (0.055)	0.0094 (0.102)	0.2787 (0.050)***	0.0358 (0.054)	0.0722 (0.087)
Later stage	-0.0056 (0.044)	0.1000 (0.058)*	0.0937(A) (0.289)	0.0030 (0.042)	0.1473 (0.055)***	n.a.
Full set of controls	yes	yes	yes	Yes	yes	yes

Notes: *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. For control variables, see Table 6 (here firm-fixed effects are replaced with industry dummies at the 2-digit level). (A) Fixed-effect estimation results (due to non-convergence in SEM-estimation). Estimation of treated and control group.

7.2. By VC spells, investment size and lags

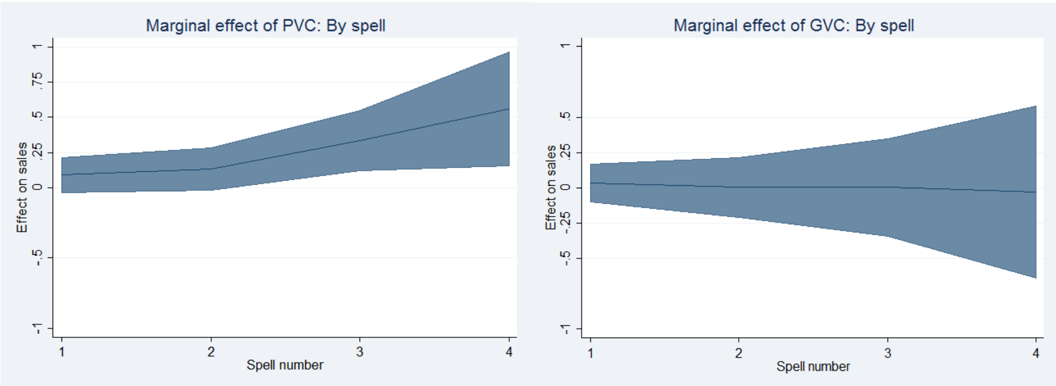
Investing capital in a firm is associated with a high level of engagement from the investor. If the firm fails, the investment is lost. Therefore, it can be rational for an investor to follow up an initial investment. Approximately one-third (31 percent) of the firms in our data receive one tranche of VC only, the mean number of tranches received is 3.8 and the maximum number of tranches received by a single firm over the period 2007-2013 is 47. Repeated investments can be considered a quality indicator; the firm succeeds in attracting multiple VC investments. At the same time, repeated VC injections can also signal problems raising internal capital and the investor's protection of investments sunk in the firm. Thus, the question of whether multiple tranches signal firm growth or financing problems is to some extent an empirical question. In addition to the signal value of repeated tranches, the impact of the later tranches can interact with lagged effects from earlier tranches.

To analyze whether the impact of VC changes over time, in Table 14 we analyze the impact of VC by separating the analysis by yearly VC spells. The marginal effect of each subsequent VC spell is depicted in Figure 5. The results suggest an increased impact on sales from each subsequent spell of private VC. The increased effect can be partially attributable to remaining post-treatment effects from previous VC injections but also be a signal of fast growth. For GVC we cannot detect an increasing effect on sales from each subsequent VC spell. To some extent, these results are in line with Buzzachi et al. (2013), who noticed that European VC firms with a higher level of public funding tend to support start-ups for a longer time after the initial investment, even when the return on the investment is mediocre.

Table 14. The impact of VC on sales. CEM-matched control group.
By VC spell. FE-estimations.

	All firms	**Private VC**	**Public VC**
VC Spell 1	0.0382 (0.046)	0.0899 (0.064)	0.0347 (0.067)
VC Spell 2	0.0249 (0.068)	0.1333 (0.076)*	0.0029 (0.108)
VC Spell 3	0.1791 (0.086)**	0.3351 (0.109)***	0.0025 (0.176)
VC Spell 4	0.3413 (0.141)**	0.5587 (0.206)***	-0.0302 (0.311)
Full set of controls	yes	yes	yes

Notes: *,** and *** indicate significance at the 10, 5, and 1 percent levels, respectively.
For control variables, see Table 6. In CEM estimations, firm-fixed effects are replaced by industry dummies at the 2-digit level. Because of a lack of observations for higher-order spells, the analysis is restricted to a maximum of four years spell count.



Note: Based on estimates from Table 14.

Figure 5. The impact of VC on sales per yearly VC spell.

We also test the robustness of the results to how VC impacts sales by replacing the VC(t) dummy with the log of the actual annual amount of VC received and lagging the covariates. These results are displayed in Table A1 in the Appendix. The results from the robustness check can be summarized as follows. First, replacing the VC(t) dummy with the size of the investment does not alter the results found in Table 7. If anything, there is a slight increase in the post treatment dummies, whereas the insignificance of VC at the treatment year remains. There is, however, a positive drift in the estimates of the contemporary effect of VC from negative and insignificant to positive and insignificant. One reason that the results seem to be robust with respect to the use of a VC dummy or the actual amount of capital invested could be how VC works. Typically, a VC investor adjusts the size of the investment according to the firm's needs. In other words, the size of the VC investment is—to some extent—endogenous. Therefore, what matters is that a VC investment is made, not the size of that investment.

Finally, applying lagged covariates is a common way to tackle potential endogeneity and impact lags. Given strong exogeneity, lagged covariates can solve endogeneity problems. This technique is especially useful when valid (contemporary) instruments are lacking (Hendry, 1995). As shown in Table A1, using lagged covariates does not alter either the estimated impact or the dynamic pattern of VC on firm sales, with the exception of GVC, which now returns a stronger and more positive impact for the year of investment. In other words, the dynamic pattern of the impact of VC on firm sales is similar when using the investment dummy as when using the (log) sum of the investment with lagged or contemporary covariates. Thus, changing the model specification does not upset the results.

8. Concluding remarks

Since 2010, the influence of governmental VC has been steadily increasing in Sweden. Given the growing role of GVCs, one might presume that they have a proven record of accomplishment and that a well-identified market failure motivates their role. Here, we analyze the motives and performance of GVC interventions in Sweden. It should be noted that VC is merely one source of financing for young and innovative firms. Alternative sources for these firms include, e.g., crowd funding, loans, grants, and business angels. Despite the existence of several funding alternatives, it is recognized that the market tends to undersupply financial capital for these firms, causing a so-called funding gap.

In short, the state's motivations for intervening in the VC market are that normally, the entrepreneur is unwilling to fully disclose her strategy, innovation technology, and business operations. From the investors' perspective, the difficulty of gathering information constitutes a significant hurdle in the form of a transaction cost. This causes market mechanisms to malfunction, leading to problems of adverse selection and moral hazard (Lerner, 2002; Akerlof, 1970), which is the most striking for young ventures with little if any cash flow and/or no collateral to pledge for credit (Lerner, 2002). Although VC investors are especially well equipped to resolve the principal-agent problem, there are reasons to believe that their effort is inadequate. As a result, the total supply of PVC might not be enough to fully remedy the dearth of financial capital for start-ups. It has also been argued that private VC companies prefer larger investments and are more shortsighted than GVCs. In addition to the capital market argument, GVC injections can also be motivated by the fact that innovations' "social returns" are larger than their private returns, thus suggesting that GVC should target innovative start-ups (Lerner, 2002). Finally, it is argued that GVC can catalyze the development of an immature VC market and start-up ecosystem.

A major critique of GVC interventions is that it can *crowd out* PVC investment. GVCs can also be criticized for their inefficiency, incompetence and lack of incentives, the fact that they are governed by political instead of economical rationales and the fact that GVC can be a way for politicians to compensate for failures in other policy areas. There is also a risk of corruption and cronyism associated with GVCs. However, an international outlook shows that GVCs are present in many countries (including the EU and Sweden) in which they seem to be increasing their influence in the VC market.

The results of this study can be summarized as follows:

- Firms receiving any form of VC experience increased sales 2-3 years after the VC investment.
- The increase in sales is partly due to increased efficiency and partly driven by increased investments. There are however no signs of a positive employment effect within four years of receiving VC.
- There is no robust evidence of a significant difference between PVC and GVC. If anything, there is a tendency of more positive effects from PVC than from GVC. This finding can be considered an indication either of GVC investors doing a good job, or of GVCs not taking more risk than PVCs.

- There are indications that GVC investors are more prone than PVC investors to hold on to, and continue to invest in stagnating, non-growing firms.
- Contrary to the theoretical motivation for GVC intervention, PVC investors allocate about the same share of total VC investments in seed financing (slightly above 2 percent of total VC capital). It may be tempting to recommend GVC to increase their focus toward seed investments. However, little is known regarding to what extent there is a seed-funding gap in Sweden. This issue should be further analyzed.

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Appendix

Table A1. Dependent variable, firm sales. Fixed effect models. Matched non-treated firms included. Treatment variable with the size of the VC investment.

	1. PVC	**2. GVC**	**3. MVC**	**4. PVC**	**5. GVC**	**6. MVC**
	Contemporary control variables			Lagged control variables		
VC (t)	-0.0043 (0.007)	-0.0086 (0.009)	-0.0105 (0.0142)	0.0007 (0.010)	0.2738 (0.094)***	0.0177 (0.017)
VC (t+1)	0.1983 (0.072)***	0.1748 (0.0792)**	0.0327 (0.134)	0.1263 (0.089)	0.2503 (0.163)	0.1805 (0.169)
VC (t+2)	0.2204 (0.074)***	0.3129 (0.1159)***	0.1947 (0.121)	0.1602 (0.091)*	0.2503 (0.163)	0.1736 (0.145)
VC (t+3)	0.3115 (0.087)***	0.3194 (0.141)**	0.3269 (0.142)**	0.2273 (0.099)**	0.3633 (0.129)***	0.4259 (0.163)***
VC (t+4)	0.3717 (0.114)***	0.4448 (0.146)***	0.4207 (0.151)***	0.4250 (0.122)***	0.5143 (0.174)***	0.4890 (0.209)**
Full set of controls	yes	yes	yes	yes	yes	yes

Notes: *, **, *** indicate significance at the 10, 5, 1 percent levels respectively.
Robust standard errors clustered at the firm level. For control variables, see Table 6. CEM-matched control group. This table replicates Table 7 with the VC(t) dummy replaced with the log of VC investment. Estimation 4-6 use lagged covariates.