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A comparison of the innovation performance of European entrepreneurial firms backed by Corporate Venture Capital and Independent Venture Capital

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Abstract

Corporate venture capital (CVC) has seen an enormous rise in Europe over the past decade, however, this has been scarcely researched in terms of its impact on innovation. This paper is the first one to examine the impact of corporate venture capital (CVC) on the innovation, measured as number of patents granted and number of citations per patent, of public portfolio firms in comparison to firms backed by independent venture capital (IVC) in Europe. The results of our fixed effects model show that companies backed by CVC have higher rates of innovation performance but lower quality innovation in comparison to their peers backed by IVC in the period under consideration (2000-2020). The selection effect has been mitigated by using propensity score matching. Our findings contrast previous research in the USA and thus provide novel insights on the effectiveness of different types of venture capital in Europe. Our results imply that different strategies are necessary to nurture both quality and quantity of innovation.

Keywords: Corporate Venture Capital; Independent Venture Capital; Innovation; Performance Measurement; Patents; Citations; Start-Ups; Europe; Publicly Owned Firms

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List of Abbreviations

CVC	Corporate Venture Capital
IVC	Independent Venture Capital
IPO	Initial Public Offering
PSM	Propensity Score Matching
R&D	Research & Development
EBITDA	Earnings Before Interest, Taxation, Depreciation and Amortization
ROA	Return on Assets
LP	Limited Partner
GP	General Partner
IP	Intellectual Property

1. Introduction

The European venture capital landscape is diverse and fragmented, with significant variations in terms of investment strategy, fund size, and geographic focus. According to the European Private Equity and Venture Capital Association, the vast majority of venture capital investments in Europe come from independent venture capital firms (IVCs), which suggests that IVCs play an essential role in the funding of start-ups (European Private Equity and Venture Capital Association, 2021). However, corporate venture capital firms (CVCs) have been on the rise in the European market, with many large corporations investing in start-ups through dedicated venture capital funds.

Funding is crucial for the success and growth of a start-up as it transitions into a mature firm. The two main sources of funding for start-ups are CVC and IVC. However, the optimal organizational structure that European corporations should adopt to foster innovation remains unclear as the two main forms of funding; CVCs and IVCs, have differing structures, objectives, and horizons. Most of the research in the USA seems to suggest that CVC investment improves innovation outcomes within the US markets, although some opposition exists. There is limited research of the benefits in European markets. Hence, the scope of this research is to determine whether CVC better nurtures innovation in the European venture capital ecosystem.

1.1 Comparison of IVCs and CVCs

CVCs are the investment branch of a larger non-financial parent company, whose primary objective is to invest in ventures on behalf of the parent company to pursue broader strategic objectives. They typically invest in start-ups that have the potential to offer synergies to their parent companies, such as access to new technologies or markets, or the potential for collaboration on research and development (R&D) projects. Siegel et al., (1998) identify acquisition opportunities as one of the most important drivers for CVCs. Benson & Ziedonis (2010) verify this by finding that one of every five portfolio companies backed by the 61 most prominent corporate investors in the USA between 1987 and 2003 is purchased by its corporate investor. As a result, CVCs tend to have a longer-term investment horizon and a relatively unconstrained supply of capital from the parent company.

In comparison, IVCs are structured as partnerships that raise capital from limited partners (LPs), such as institutional investors or high net worth individuals, and invest in start-ups in exchange for equity ownership. Their primary objective is to maximize financial returns for their investors, and they typically have a shorter-term investment horizon of 10 years due to restrained fund draws based on the amount of capital committed by LPs. IVCs focus on start-ups with the potential for rapid growth and high returns, often in emerging industries or disruptive technologies.

These differing structures result in CVCs and IVCs also having different managerial compensation structures and incentives (Dushnitsky & Shapira, 2008). GPs (General Partners) in IVCs are compensated by a management fee and carried interest (also known as a performance fee). Meanwhile, CVC fund managers are typically compensated with a fixed salary and a bonus, dependent on the performance of the parent company. There exist plenty of research on executive incentive design and risk-taking, where most studies suggest that performance-based fees increase risk-taking behaviour. Fixed compensation structures provide less incentives for risk-taking, rather stimulating risk-averse behaviour to maintain a good reputation and their occupation (Aggarwal & Samwick, 1999).

Despite these differences, CVCs and IVCs share some similarities. Both forms of venture capital provide funding and support to start-ups and early-stage companies that have high-risk, high-reward potential. They also play an important role in promoting innovation and entrepreneurship by providing start-ups with access to capital, expertise, and networks of industry professionals. Additionally, both CVCs and IVCs face similar challenges, such as managing risk, selecting, and nurturing high-potential start-ups, and achieving successful exits.

In conclusion, while CVCs and IVCs share some commonalities, such as promoting innovation and entrepreneurship, they differ in their investment strategies and objectives. CVCs focus on generating strategic returns for their parent companies, while IVCs focus on generating financial returns for their investors. As corporates often establish venture capital firms for the purpose of capturing innovation, their focus on strategic fit rather than mainly financial objectives set them apart from IVCs. The differences between corporate and independent venture capital firms create a natural test case for research on the impact of organizational structure and strategy on the performance of investments.

The remainder of this paper is divided into the following chapters. The second chapter will discuss the existing literature up until present as well as the research gap. The third chapter will include our hypotheses regarding the impact of CVCs on innovation as well as our rational behind them. The fourth chapter will include the data and sample collection, examining how we collected and transformed our data. In the fifth chapter, we will focus on the methodology and how we conduct the propensity score analysis and OLS regressions. The results of our analysis will be displayed in the sixth chapter. The conclusion and discussion can be found in chapters 7 and 8 respectively, where we analyse the implications of our paper, state limitations and provide recommendations for future research.

2. Existing literature & research gap

With the increased practice of CVC over the past decade has come new research on the rationale behind CVC, the drawbacks, and the potential advantages for start-ups in comparison to IVC-backing. The value of corporate investments has increased more than tenfold over the past decade, currently representing 21% of all venture capital investments versus only 11% ten years ago (Rohrer et al., 2022). Firms like Motorola, Xerox, and Johnson & Johnson have long-established corporate venture capital programs, dating back to the 1960s. From the 1970s onwards we observe a large rise in activity of corporate venture capital firms in the USA, with about 450 corporations running a program by 2000 (Benson & Ziedonis, 2010). The majority of firms backed by CVC pertain to the information technology industry followed by the biotechnology industry. The growth of corporate venture capital in Europe kicked off much later, roughly the last decade (Rohrer, 2022). In 2018, the EU launched a program to double venture capital investments to narrow the gap with the US and China (European Commission, 2018). The number of corporations running CVC programs up until 2000 was just 60 according to the Refinitiv Eikon database. To compare, Europe has recently reached 564 CVC firms (Refinitiv Eikon). Due to the historically and currently larger size of the corporate venture capital climate in the USA, the USA has been extensively researched, whereas research on the European investment climate regarding CVC has been lagging (Benson & Ziedonis, 2010).

Historically, American venture capital funds have significantly outperformed funds in the EU (Bekaert et al., 1989). Schwarzkopf (2016) shows that the USA facilitates faster growth and international expansion of start-ups than the EU. Distinctive features between the USA and Europe include cultural differences, size of funds, and investment strategy. The open culture towards entrepreneurship, higher tolerance for failure and common risk financing in the USA creates a more entrepreneurial ecosystem than in Europe (Bertoni et al., 2015). In terms of size, USA funds are on average larger than European funds. Although larger fund size is not directly linked to better performance in research, it does indicate easier access to capital (Bekaert et al., 1989). The venture capital market in the USA has the capacity and competence to invest in all stages, therefore having the ability to support firms along their growth cycle (Schwarzkopf, 2016). Europe is underperforming in terms of growth capital (European Investment Bank, 2023). Scale-ups frequently turn to London for late-stage investments and in large funding rounds there is often an US investor in the lead, since the US has much more growth stage capital available (Schwarzkopf, 2016). Investing in different rounds with different ticket sizes has implications on the outcome in terms of returns for the venture capital firm, but also for innovation power for start-ups. This brings us to the difference in investment strategy; research states that USA funds prioritize a strong product-market fit over revenue and profitability (Bertoni et al., 2015 & Schwarzkopf, 2016). Overall, funds in the USA have a larger risk appetite than funds in Europe, facilitated by the size of their funds, their expertise in all stages of investment and their culture. Europe's investment culture has been reported as slightly more cautious and conservative (Bertoni et al., 2015 & Schwarzkopf, 2016). As differences in investment practices can be observed between the two continents, research on CVC in Europe could give rise to different results and new insights. Our paper contributes to the emerging body of literature by exploring innovation in portfolio firms nurtured by corporate venture capital versus independent venture capital in Europe.

It is vital for founders of companies to evaluate both sources of funding and how they may impact their growth and innovation objectives. Most research up to this point has been on the performance of the parent company of the CVC instead of the portfolio company. The performance of the parent company has been measured in several ways. Allen and Hevert (2007) investigated the impact of CVC activities on the direct financial return, where financial return is measured in IRR, cumulative net cash flow over program duration, and cumulative parent EBITDA. The study showed that there is wide dispersion in financial return to the CVCs and little evidence for direct attractive financial return. Gompers and Lerner (1998) show that performance, measured in profitability, is higher for firms with a strategic fit with the CVC parent company. Value destroying programs, on the other hand, are associated with participation in later investment rounds, irregularities in annual investment activities and less active harvest positions (Allen & Hevert, 2007). Other factors that have been identified explaining the differences in returns are program scale, write-downs, agency problems and managerial overconfidence (Benson & Ziedonis, 2010). Other measures used in literature as proxy for performance are IPO rates and post-IPO valuation (Gompers & Lerner, 1998; Maula & Murray, 2017). These studies conclude that post-IPO valuations are higher for companies (co-)financed by CVCs, whereas IPO rates are only higher for businesses that are related to their CVC investors. In conclusion, there is little evidence on consistent better performance, in terms of higher financial return, for CVC investors.

A different metric in the existent literature to measure performance is the innovation level. Patent count and patent citations are the most accurate variables to be found in current literature to measure innovation. Chemmanur et al. (2014), Dubocage and Shuwaikh (2022), and several others investigated the impact of CVC versus IVC companies on their portfolio companies' innovation rate. They report that CVC-backed firms are more innovative because of the technological fit between parent firm and portfolio firm as well as greater tolerance for failure. Several authors have documented how companies with CVC-backing can benefit from parent firms' knowledge of technologies and markets as well as financial resources, manufacturing facilities, research laboratories, and various kinds of complementary assets such as legal support for patent applications (Allen & Philips, 2002; Dushnitsky & Lenox 2005; Eisenhardt et al., 2008). Bae and Park (2018) emphasize the influence of the timing of the CVC investments and the number of patents the portfolio company already had before the CVC investment. However, they do not find that start-ups backed by CVCs outperform those backed by IVCs in terms of innovation. Bae and Park (2018) and Kang et al. (2018) propose that the incentives of IVCs and start-ups are more aligned as opposed to CVCs controlled by a parent firm that could engage in misappropriation of technologies and patents invented by the start-up. However, this research assessed a niche market, biotechnology firms in the US, and therefore does not represent the entire CVC ecosystem. Dushnitsky & Lenox (2005), for example, demonstrate that CVCs are better able to capitalize knowledge in industries with weak Intellectual Property (IP) regimes, such as the information and devices sector, and are therefore more driven to enhance innovation rates of the backed companies in those industries. In short, there is no complete consensus within the existent literature on the ability of CVCs in the US to better nurture innovation. Previous literature reveals discrepancies in innovation levels between CVCs and IVCs, potentially driven by the industries that CVCs and IVCs operate in, but other drivers of the inconsistency in outcomes, such as tolerance for failure, technological fit, and timing, have been posed as well.

Most previous research has exclusively focused on the US. Bider and Gigante (2021) are the first authors to recently address the impact of CVCs on performance and innovation rate for the European continent. However, this research only considers the added innovation to the parent companies of the CVC firm. They illustrate that, in line with most results from the USA, CVCs have a positive impact on innovation of the parent firm. An interesting but unexplored angle in the current research on Europe is how differing investment strategies affect the innovation performance of the portfolio company rather than the parent firm. Hence, we aim to bring to light the impact of CVC investments on start-ups operating in all industries in the entire European market, an area with little prior research.

Based on the previous findings of existing literature, our paper will be the first to focus on the innovation performance of European CVC-backed companies as measured by patenting activity. A new field of research that complements the findings from the studies on the US CVC ecosystem but also highlights potential differences between the two geographies.

3. Hypotheses

This thesis aims to investigate the effect of CVC funding on the innovation performance of the CVC-backed companies. Our hypotheses are based on the existent literature and the prevailing research conducted in the US market.

3.1 Innovation Quantity: patent count

Null hypothesis

> **H1.0:** There is no difference in the total number of patents generated by European listed companies backed by CVCs in comparison to those backed by IVCs in the period under consideration (2000-2020).

This hypothesis suggests that CVC firms are not superior to IVC firms at nurturing innovation in their portfolio firms, in fact they perform equal. The differences in structure, compensation and strategy that exist between IVC and CVC firms do not affect patent production by their portfolio firms. They face similar challenges in managing risk, selecting, and nurturing high-potential start-ups and achieving fruitful exists. The differences observed in the USA are a result of their culture and the structure of their entrepreneurial ecosystem, which are not observed in Europe.

Alternative hypothesis: two-sided

H1.1: The total number of patents generated by CVC-backed companies is higher than for IVC-backed firms in Europe in the period under consideration (2000-2020), implying CVCs nurture innovation better.

Based on the existent empirical research on the US and the prevailing literature, this hypothesis suggests that CVC-backed firms produce more patents than IVC-backed firms with similar characteristics. Higher innovation of CVC-backed firms can be particularly attributed to the emphasize on strategic objectives, implying longer investment horizons and higher tolerance for failure, and the availability of complementary assets relevant to start-ups with a close technological fit (Chemmanur et al., 2014; Dubocage & Shuwaik, 2022).

CVCs receive funding from their large established corporate parent, which is a relatively unconstrained supply of capital. This capital is provided with the aim of maximizing the overall corporate parent firm's value, not through immediate financial return, but through strategic partnerships. Benefits of strategic partnerships include a window on technology, corporate diversification, tapping into foreign markets, improving innovation in existing business, seeking new acquisition opportunities, and assuring demand for their own products (Deck, 2008). These pursuits complement the corporate parent's internal R&D. CVCs profit disproportionally from strategic partnerships compared to IVCs, as they increase the parent firm's profits on top of the portfolio companies' profit. As CVCs do not have limited partners that invest, they are less time-constrained in their search for innovation and have a higher tolerance for failure. This suggests that CVCs are more patient in their investment approach and more willing to continue supporting start-ups through periods of uncertainty or failure, leading to the greater innovation and patent generation. This approach, together with the vast amount of complementary assets they possess, including resources but also specialized knowledge and expertise of the industry, seems to setup CVCs better in their endeavour to nurture innovation in the portfolio firm.

Previous empirical research in the US shows that CVC-backed firms indeed experience greater innovation. A prominent paper by Chemmanur et al. (2014) discovered that in the US market, CVC-backed firms generate 26.9% more patents than IVC-backed firms in the three years prior to IPO. In the four years after IPO, CVC-backed firm generate 44.9% more patents. Other research in the US confirms these results (Dubocage & Shuwaik, 2022, Lenox & Dushnitsky, 2005). Hence, it can be expected that European markets will follow a similar theme, although the correlation is unknown due to the differing VC ecosystems between the two markets. Given that innovation in young entrepreneurial firms is not consistently occurring immediately after investment, our hypothesis is set up to measure the total innovation that has accumulated over a time period of 20 years. A similar setting can be found in Lerner et al.'s (2011) work. This is also in line with the longer time periods of investments that CVCs uphold.

H1.2: The total number of patents generated by IVC-backed firms is higher than for CVC-backed firms in Europe in the period under consideration (2000-2020), implying IVCs nurture innovation better.

Contrary to the previous hypothesis, theory and empirical research exist that find IVCs to be the better candidate in nurturing innovation. Bae and Park's (2018) research is one of the sources that highlights that CVCs do not outperform IVCs when it comes to innovation of their portfolio firms. Other research emphasizes that only under certain boundary conditions, such as a weak intellectual property regime, high reputation, or specific technological fit, CVCs produce higher innovation outcomes (Allen & Hevert, 2007). Bae and Park (2018) accentuate the role of an CVC investment as an exploitative rather than an explorative strategy for corporate innovation. This study explains that IVCs and their portfolio firms have better aligned incentives since they do not compete for the outcome of innovation activities and therefore cooperate better to create value. CVC firms, on the other hand, have parent companies with double-edged incentives competing with the portfolio firms to appropriate the innovation created (in the form of patents) by the portfolio firms. Moreover, establishing equity links with one corporate investor might limit other collaborations in the future, as investors with a competitive interest to the parent firm of the CVC could be reluctant to work together. Seru (2014), additionally, argues that the centralized resource allocation and corporate socialism associated with CVC impairs the development of innovation. Moreover, CVCs are subjected to fluctuations in financial performance of their parent firms.

IVCs, on the other hand, are found to have more efficient research allocation and more autonomy to support their investees. IVCs often also focus on a specific industry, giving them specialized knowledge just like CVCs, while having seasoned investment professionals with expertise on how to build and grow a firm (Park & Steensma, 2013). IVCs have extensive experience in the field, being established in the late 1940s and early 1950s, while CVCs are a newer phenomenon in Europe (Hodgson, 2023). Finally, the earlier mentioned executive incentive design of IVC firms, based on a management fee and carried interest, has a proven positive effect on innovation as independent venture capitalists have more incentive to pick more risky but eminently novel start-ups (Aggarwal & Samwick, 1999).

3.2 Innovation Quality: citations

Null Hypothesis

H2.0: There is no difference in the number of citations per patent generated by European listed companies backed by CVCs in comparison to those backed by IVCs in the period under consideration (2000-2020).

This hypothesis suggests that patents from CVC-backed firms do not get cited more frequently compared to patents from IVC-backed companies. In fact, the results show no difference, suggesting that CVC-backing does not necessarily lead to higher quality innovation, irrespective of the total amount of innovation measured by patent count.

Alternative hypothesis: Two Sided

H2.1: The total number of citations per patent generated by CVC-backed companies is higher than for IVC-backed firms in Europe in the period under consideration (2000-2020), implying CVCs have a positive effect on the quality of innovation.

Regardless of whether CVCs or IVCs are superior at advancing the quantity of innovation, this hypothesis suggests that CVCs are better at enhancing the quality of innovation. Most of the reasoning that argues in favour of hypothesis H1.1, also holds as argument to defend this hypothesis, H2.1. The broader investment objectives of CVCs compared to IVCs, with next to financial returns, also strategic value, gives portfolio firms more space to carry out their pursuits of innovation. Additionally, we identify some mechanisms in the literature that are specifically linked to quality. For strategic reasons, CVCs generally invest in firms that are closely related to their parent firm's industry. Chemmanur et al., 2014 provides evidence that a close technological fit enhances the quality of innovation. IVCs often specialize as well and have expertise knowledge, however, they generally not own beneficial complementary assets such as laboratories and machinery. CVCs moreover have the extra incentive to provide specifically tailored resources for innovation, as they will disproportionally benefit from this compared to IVCs (Duubocage & Shuwaikh, 2022). Superior access to excellent resources and high value collaborations increase the quality of new technologies and lead to more innovative products and services. Finally, CVCs higher tolerance for failure and longer time horizons specifically impact quality as this allows the ventures to deep dive in ideas. Ventures with resource constraints for innovation will likely assess the opportunity cost of innovation and the impact on their profitability and the investors' capital gain. Resource constraints are expected to occur more frequently for IVC-backed firms as innovation is only one of the eight drivers of performance (Park & Steensma, 2013).

H2.2: The total number of citations per patent generated by IVC-backed firms is higher than for CVC-backed firms in Europe in the period under consideration (2000-2020), implying IVCs have a positive effect on the quality of innovation.

Contrary to the previous hypothesis, CVC-backing may have a negative impact on the quality of innovation for the portfolio company. The main objective of a CVC is to provide both financial and strategic value to its parent company. The parent company often has a specific strategy in mind and could be more interested in technologies that complement its existing business rather than truly disruptive innovations (Gompers & Lerner, 1998). Hence, this may limit the quality of innovation seen in CVC-backed companies as well as narrow their focus. IVCs, on the other hand, are always looking for the next unicorn to maximise returns. They have a sharp focus on discovering technologies and products that are commercially interesting and instigate broad interest, which can result in more unique innovation and thus higher quality of innovation. One study by Narin et al. (1997) found that patents with higher numbers of citations tend to have greater economic value. IVCs therefore have a strong incentive to invest in companies that create high quality patents as this directly transfers into financial returns. In addition, IVCs are not limited in their collaboration with partners, bringing the opportunity to bring in more diverse knowledge of for example universities and research institutions, but also other players in the industry. Moreover, they have the opportunity to create synergies within their portfolio. These firms might be further apart in terms of technological fit, but this could result in more unique insights. Dushnitsky & Lenox (2005) and Dubocage and Shuwaik (2022) show that a narrow technological fit reduces absorptive capacity and the learning curve, resulting in lower quality. A final theory by Park and Steensma (2013) suggests that CVCs are less pressured in terms of time and resources, overly allocate resources to R&D as a result, and thereby stimulate unproductive outcomes and suboptimal quality. They lack the sharp focus, driven by financial performance, that IVCs have.

Theory thus indicates that both CVCs and IVCs possess unique qualities that are beneficial or restraining for enhancing innovation, both quality and quantity. Empirical evidence is therefore necessary to prove which mechanisms are the dominating factor in boosting innovation in portfolio firms in Europe.

4. Data and sample selection

To test our hypotheses, we require data on all IVC and CVC firms in Europe, the companies they have backed, and a selection of characteristics of those companies, such as size and profitability, that will function as control variables. Besides, we need the number of patents these companies have produced and the number of citations per patent to measure innovation. Innovation is not implemented overnight but created over an extended period of time. For this reason, we measure patent creation over a prolonged period to accurately estimate innovation. As corporate venture capital in Europe has only prospered over the past one to two decades, we have set our measurable period on 2000-2020.We therefore also measure all control variables over a period of 20 years. Another reason for the use of panel data over the period 2000-2020 is to create a meaningful sample size of public portfolio firms. Compared to the US, the EU has been slow in developing a strong venture capital environment and therefore the data sample of suitable firms is smaller. A similar 15-year panel data analysis has been performed by Dubocage & Shuwaikh (2022).

4.1 Identifying CVC and IVC-backed Companies

Data on both CVC and IVC activity in Europe has been collected from the Refinitiv Eikon database which provides access to industry leading data and is a prominent database for CVC research (Röhm, et al., 2020). Firstly, we use the private equity screener in Refinitiv Eikon (formerly known as VentureXpert) to screen the total number of CVC firms and IVC firms in Europe that have made investments between 1990-2022. This time period was used to obtain a sufficiently large and thereby meaningful sample of CVC-backed IPO companies. The screener contains detailed profiles of over 22,000 private equity and venture capital firms globally, as well as comprehensive profiles for over 133,000 current and former private equity and venture capital backed companies. The data cleaning process is in line with previous papers examining CVC activity in the US Market (Chemmanur et al., 2014). We apply multiple screens to extract the required data, these include using the 'Venture Capital Deals' screen, selecting the investment data between 1990 and 2022, 'Firm Investor Nation' and 'Investee Company Nation' to Europe and 'Investee Company Current Public Status' to public. We also filter for 'Corporate Investment' when collecting the CVC-backed firms. We obtain a total of 564 CVC firms when searching for venture capital firms with the 'corporate investment' screen; this is after excluding undisclosed firms and firms with a foreign or unknown parent. Additionally, using the same process, we gather 3018 IVC firms with 'non-corporate investment' that made investments over the same period.

We then retrieve the total number of companies backed by these firms over this period in Refinitiv Eikon. In accordance with previous literature, we identify a firm CVC-backed if it receives financing from at least one CVC investor. In the entire European market, we collect a total of 3378 companies backed by CVC. However, as with previous US literature, we focus our research on public companies due to the lack of data available for private firms. Hence, we narrow our search to public companies over the same time period. We find that 110 CVC-backed companies IPOed and a total of 1192 IVC-backed companies IPOed during the time frame. It should be noted that over the time frame, a number of IPOed companies have either been a) acquired by another firm, b) dissolved or c) de-listed. We control for this in our analysis by evaluating the data over 20 years and use the data of the years we have available for those firms.

Our data from Eikon shows that, as seen in previous research, healthcare and technology companies are the largest receivers of CVC funding in our sample. There is also a much higher concentration of industry type when compared to IVC-backed companies. Additionally, detailed breakdowns of the demographics of CVC and IVC-backed IPO firms in our sample can be found in figures 1 and 2. The most notable aspect of these graphs is the high proportion of companies in France which have received CVC investment in comparison to IVC investment. The French government has implemented policies to support CVC investment, such as tax incentives for corporations that invest in start-ups and innovation funds that provide co-investment opportunities for CVC investors, such as the "Programme d'investissement d'avenir" (Investments for the Future Program).

The United Kingdom represents a significant portion of both Europe's IVC and CVC-backed companies that have gone public. Due to London's leading position as a global financial centre in Europe, it comes as no surprise that many successful IVC and CVC-backed firms are located here and take advantage of London's access to capital.

Figure 1: Demographic Breakdown of CVC-backed Companies (N=104)

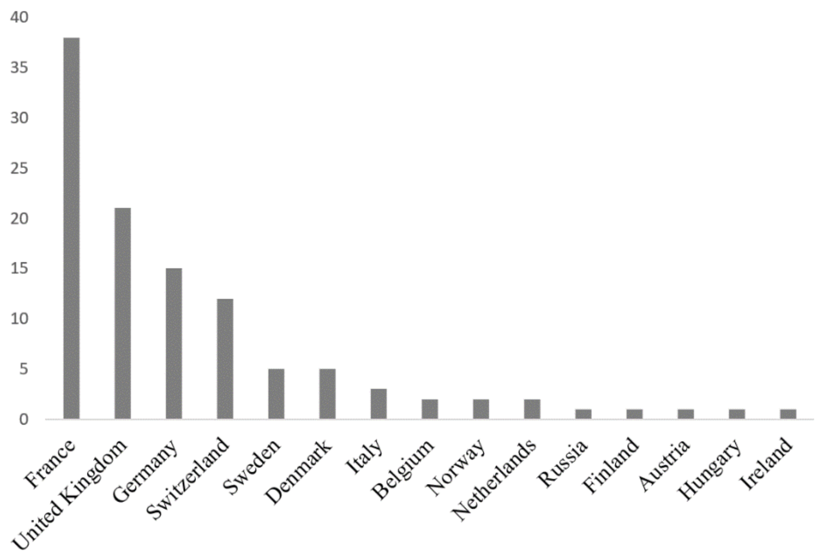
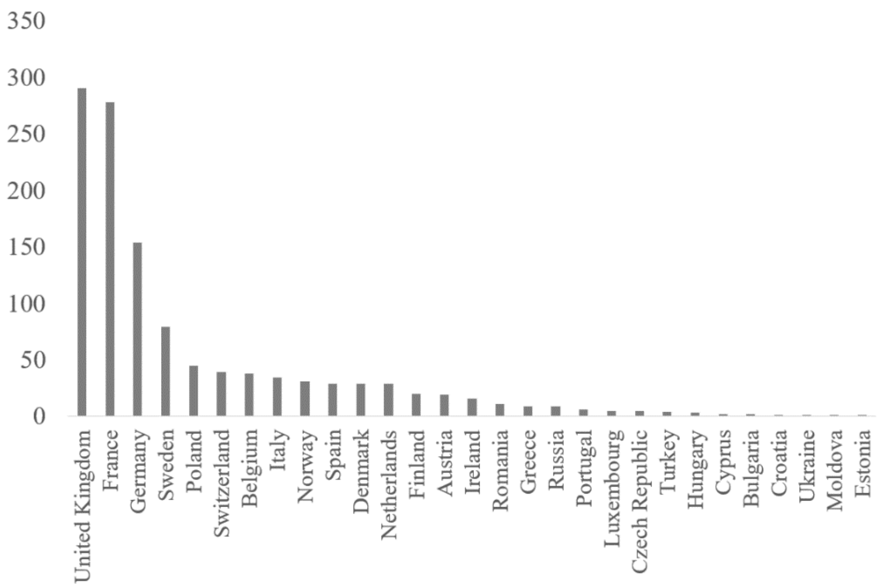


Figure 2: Demographic Breakdown of IVC-backed Companies (N=1192)



4.2 Measuring Innovation

4.2.1 Patents

A common measure of innovation for companies used in existing literature is the number of patents produced (e.g., Chemmanur et al., 2014; Kogan et al., 2012; Seru, 2012). Several previous studies have also used R&D as a measure of innovation activity, however, patent-based measures are better indicators as they are a direct measure of the output of the innovation process and represent legally recognized innovations or inventions. In contrast, R&D expenditure is an input measure that reflects the resources allocated to innovation activities but does not directly measure the outcomes of those activities (Pisano and Shih, 2012). In addition, several studies have found that patent-based metrics are better predictors of financial performance than R&D expenditure. For example, Hall et al. (2005) found that patent counts were significantly associated with firm value, while R&D expenditure was not.

It is common practice for US CVC research to use the National Bureau of Economic Research (NBER) to obtain patent data. However, as this is only limited to the US market, we obtain our data from the Online European Register (see Rogier, 2003 for more details). The database is the most complete and up-to-date source of publicly available procedural information on European patent applications as well as grants, including applicant name, filing date and date of grant.

The number of patents granted for each company was obtained for each year between 2000 and 2020. The reasoning behind ‘granted’ patents instead of ‘applied for’ patents was that granted patents represent a tangible output of the innovation process that has been recognized by a patent office as novel, non-obvious, and useful. Applied for patents, on the other hand, only represent a potential output of the innovation process, as the patent office has yet to review and grant the patent. Hence, using granted patents as a measure of innovation provides a standardized and objective way to assess innovation between CVC and IVC-backed companies. Contrary to the NBER, the Online European Register does not provide running batch data, so patent data had to be counted and filled in manually for every firm over the 20-year time period. We perform a natural log transformation on the patent data to reduce the extreme effect of outliers and to make the results easier interpretable.

It should be noted that the use of patent activity is not without limitations when it comes to measuring corporate innovation. Different industries have various innovation proclivity and duration. Moreover, younger firms might abstain from patenting for competitive reasons. Therefore, fewer patents generated in a particular industry may not necessarily translate into that industry being less innovative. However, we believe that we can alleviate this concern through our controls that will be used in the PSM, mentioned in section 4.3, allowing us to accurately measure innovation between the CVC and IVC group across industries and firms.

4.2.2 Citations

In addition to measuring the quantity of innovation generated by CVC and IVC-backed IPO firms, we also examine the quality of innovation based on the number of citations for each patent. This will serve as a proxy for the impact and significance of the innovation generated by these firms.

According to the literature, citations are a key indicator of the influence and impact of scientific research. It is founded on the idea that patents that are cited more frequently by others are more influential and important than those that are cited less frequently (Normaler & Verspagen, 2008). The use of this measure has been supported by several studies in the literature (Chemmanur et al., 2014). A citation is a reference to a previous work that has been used or consulted in the creation of a new work. As such, it represents a form of acknowledgment and recognition of the value of the original work. Researchers in many fields use citations to assess the quality and importance of the work they are reading, and to determine its relevance to their own research. In the context of IVC and CVC-backed firms, citations are often used to measure the quality of the innovation generated by these firms because they provide evidence of the impact and significance of the firm's research and development activities.

Citation data is available for each patent on the European Patent Register. We manually retrieved and counted all citations for the patents of all matched CVC and IVC-backed IPO firms. The European Patent Register provides information on the publication information of the citation and groups all citations by origin (cited in “Search”, “Examination” or "By applicant") and by type ("Patent literature" or "Non-patent literature"). We create two variables for measuring the citation data; citations per patent excluding self-citations by the applicant and total citations per patent. Our main variable to accurately assess the impact of CVC-backing on the quality of innovation is citations per patent excluding self-citations by the applicant as this better captures the external impact of citations. We use total citations per patent as robustness check. Similar to patent count, we use the natural log for all citation data in our regressions.

4.3 Control Variables

We obtain financial information of all public firms using the Orbis Europe database. The financial information will serve as matching criteria during the propensity score matching as well as control variables in the regressions. Orbis Europe is a subset of Bureau van Dijk's global 'Orbis' tool that contains data on 21 million European companies. A batch search is conducted for the list of CVC and IVC-backed IPOed firms that were produced from the private equity screener in Refinitiv Eikon. We compile panel data for each firm for every year between 2000 and 2020 using the following variables in line with previous literature: industry type, total assets, R&D over total assets, EBITDA over total assets and ROA. Our reasoning behind these variables can be found below. We do not observe data on each control variable for every year, meaning our dataset is unbalanced. A small number of firms from Eikon could not be identified in the Orbis database and were therefore dropped from the sample, leaving us with 991 IVC-backed IPO firms and 104 CVC-backed IPO firms.

Industry type: The type of industry a firm operates in highly impacts the likelihood of the firm obtaining patents. Some industries have weak intellectual property regimes, others have strong intellectual property regimes. To isolate the effect of the CVC on innovation, we match on industry and use it in our regressions as control variable and fixed effect. Previous literature in the US uses the SIC, which is a hierarchical coding system used to identify and classify businesses and economic activities based on their primary function or industry in the US and the UK. The European equivalent is the NACE code. NACE is used by statistical agencies, researchers, and policymakers to analyse economic trends, track industry performance, and inform policy decisions. In our analysis, we use the NACE code ranging from A to S.

Total assets: Total assets is a commonly used variable in PSM and regressions in existent literature for as it ensures that the treatment group (CVC-backed companies) and the control group (IVC-backed companies) are well matched in terms of firm size and financial strength. Furthermore, total assets can also impact a firm's access to (external) sources of innovation such as the acquisition of innovative start-ups. Therefore, total assets could be positively correlated with innovation and therefore influence our dependent variable. As we only want to measure the effect of a CVC, this variable needs to be controlled for. We use the natural log of this variable to address the normality issue, reducing variation caused by extreme values, and making the distribution more normal. This preference for the natural log version of total assets has been confirmed by previous studies (Bider and Gigante, 2021; Chemmanur et al, 2014). Total assets are measured in thousands in our excel panel dataset.

R&D over total assets: This is an essential variable to ensure that the outcomes of the two groups are not biased with respect to innovation investment. CVC-backed companies often have access to greater financial resources from their parent companies, which can impact their innovation capabilities and performance outcomes. Including R&D expense as a control variable takes account of these confounding factors and ensure that any differences in innovation performance outcomes between the two groups are not due to differences in R&D investment. As R&D expenses were very scarcely reported for our CVC sample, we estimated the average R&D expense of IVC-backed firms per industry and used this industry average for the CVC firms in our sample. We then divided this industry average by the CVC's unique value of total assets to get the R&D over total assets variable.

EBITDA over total assets: Using EBITDA as variable in our regression allows for the control of financial performance between IVC and CVC-backed companies. This is important because financial performance can impact a firm's ability to invest in innovation and influence the results of the analysis. As with total assets, EBITDA also aids in comparing companies of similar size. We do not take the log of EBITDA, in contrast to some previous research, as we have a considerable share of negative values within our EBITDA variable. Instead, we scale EBITDA over total assets to prevent any size issues.

ROA: as with EBITDA, ROA allows for differences in financial performance to be controlled for and provides a measure of a firm's profitability relative to its assets.

5. Methodology

Our methodology primarily took inspiration from Chemmanur et al.'s (2014) research. However, as their paper is focused on the US, we had to adjust our approach slightly due to different data availability in Europe. Instead of measuring innovation three years pre and four years post IPO, we take a larger panel dataset of 20 years, as has been done by Dubocage and Shuwaikh (2022), Bider and Gigante (2021), and Lenox and Dushnitsky (2005). Based on Chemmanur et al. (2014), we test our hypotheses using Propensity Score Matching followed by regression analyses. In this section, we will provide a clear understanding of the methods used in this study, which enables readers to evaluate the validity and reliability of our findings.

5.1 Propensity Score Matching

An ideal experiment would be to evaluate the innovation of entrepreneurial firms under the random assignment of CVC or IVC investment. As such an experiment is not feasible, propensity score matching is performed to imitate random assignment. With this method we aim to exclude the theory that CVCs have superior selection abilities in identifying entrepreneurial firms with higher innovation potential before investment. This is done by disentangling the treatment and selection effect of CVC financing on the innovation output of the entrepreneurial firms based on observable characteristics. We report comparisons between these two groups of firms on their observable characteristics before propensity score matching. Tables 1 and 2 on page 22 present the firm characteristics and figures 1 and 2 in the appendix show the industry concentration for both the CVC and IVC sample. These give us insights into the extent the treatment and control groups differ from each other. The results demonstrate that CVC-backed firms are smaller (lower total assets), less profitable (lower ROA and lower EBITDA), and more concentrated in industry type compared to IVC-backed firms. PSM allows us to match our sample on chosen characteristic and thereby minimize the selection effect. The PSM is conducted in R, which is a powerful tool for statistical computing and widely used in economic research.

For our PSM we use a combination of the exact and nearest matching approach developed by Rosenbaum and Rubin (1983). The propensity scores are based on a probit regression in line with previous research by Chemmanur et al. (2014). The two matching variables used in the PSM are the average log of total assets and the industry type to absorb for any size and industry specific heterogeneity between the CVC and IVC-backed firms. We perform exact matching on industry and nearest matching on the average log of total assets. When calculating the average log of total assets for each firm, six CVC firms dropped out our sample since they had no data available for any of the 20 years. Hence, those are not utilized in our regression, leaving us with a total sample size of 98 for CVC-backed firms. All firms that have at least one datapoint for total assets are kept in the sample. We omit all datapoints in the panel data with missing total asset data for a specific year and calculate the average based on the datapoints left. Chemmanur et al. (2014) matched the total assets of the firm at IPO year when conducting their PSM. However, as we are conducting a longitudinal study, we believe that taking the average over a 20-year period provides a better picture of firm size. Some previous research matches on more variables than industry and total assets, however, there exists an intrinsic trade off in adding more variables to the propensity score matching. Adding more variables in the nearest neighbour propensity score matching would mean our match in terms of total assets and industry would be inferior. Industry is highly correlated with patent count as for example the pharmaceutical patents industry is very patent intense, whereas software is extremely hard to patent (Lenox & Dushnitsky, 2005). Research also shows that total assets is a very important factor in explaining patent generation since access to resources such as manufacturing facilities, research laboratories, and good personnel, are key in stimulating innovation (Dubocage & Shuwaikh, 2022). ROA and EBITDA are less explanatory in terms of patent generation as previous research produces insignificant coefficients for these variables in relationship to innovation or they are not even reported (Chemmanur et al., 2014; Bider & Gigante, 2021). Lastly, R&D has been shown to have a strong correlation with innovation, however as averages from IVC-backed firms are used for CVC-backed firms, we already achieve a close match between the samples. Therefore, as we consider industry and total assets as the variables with most impact on patent count, we believe it is more important to obtain a close match on these variables. Since the total number of CVC-backed firms is significantly less than the number of IVC-backed firms, by a scale of approximately 11:1 in Europe, we match on a scale of 1:1.

5.2 OLS Regression

As we have now obtained a matched set of treated and untreated subjects with a similar value of the propensity score, we proceed to estimate the difference in innovation outcome between the two groups. We explore this hypothesis statistically by using a linear regression with patent count as y variable and the CVC dummy as x variable. To measure the quality of innovation we use citations per patent as y instead. Moreover, we control for log total assets, R&D over total assets, ROA, EBITDA over total assets, and industry. All variables are measured over 20 years. Non available datapoints are omitted from the sample while running the regression.

We first run an ordinary least squares regression with only the dependent and independent variable to get a rough estimate of the relationship between CVC-backing and innovation. Next, we run the OLS regression with all control variables. We do this as we are curious to see the impact of the various industries on patent count and citations per patent. Next, we run a fixed effect model and include time and industry fixed effects. The fixed effect model has been chosen over the random effect model as the Hausman test rejected the random effect model. Our result of the Hausman test can be found in table 8 in the appendix. In the context of analysing the innovation of VC-backed firms between 2000 and 2020, time fixed effects are necessary to account for the effects of macroeconomic factors and other time-varying factors that could influence innovation levels over time. For instance, macroeconomic factors such as economic recessions or expansions can have a significant impact on the level of innovation of VC-backed firms. By including time fixed effects in the analysis, we can isolate the effect of VC financing on innovation and ensure that any observed differences in innovation levels between CVC and IVC-backed firms are not simply a result of macroeconomic conditions or other time-varying factors, such as periods of lower investment, for example, The Great Financial Crisis between 2008-2009 and the dot-com bubble between 2000-2002. Industry fixed effects are applied to control for industry specific and time invariant unobservable effects. Different industries have varying levels of innovation, where some industries are more inclined to produce patents than other. In addition, industries may be subject to different regulatory and competitive pressures that can influence the level of innovation in VC-backed firms operating in those industries. Additionally, as mentioned earlier, different intellectual property regimes affect patent outcome. By including industry fixed effects in the analysis, we can isolate the effect of VC financing on innovation within each industry and obtain more accurate estimates of the impact of VC financing on innovation. As such, we remove unobserved heterogeneity between the different firms in our data. Furthermore, we use robust standard errors to check for heteroskedasticity in our model. The results of these regressions and the differences between the models are presented in the next section.

6. Results

6.1 Propensity Score Matching: sample characteristics pre and post

To gauge the results of the propensity score matching, we first investigate how the sample of CVC-backed companies (treatment group) and IVC-backed companies (control group) before PSM differ in their observable characteristics such as firm size. We report the comparison between these two groups in tables 1 and 2. We identify some features of interest.

Table 1: Pre-Matching IVC Sample Characteristics (n=991)

Variable	mean	sd	min	max	range
ROA %	-5.10	22.47	-100.00	96.50	196.50
Total Assets (million)[1]	655.80	2934	0.0033	122518	122518
R&D/Assets	0.17	4.07	0.00	251.27	251.27
EBITDA/Assets	-0.04	0.71	-35.92	18.23	54.16

Table 2: Pre-Matching CVC Sample Characteristic (n=98)

Variable	mean	sd	min	max	range
ROA %	-13.76	28.22	-98.99	90.57	189.56
Total Assets (million)	336.79	714.26	0.03027	9085.43	9085.40
R&D/Assets	4.07	36.26	0.00	709.85	709.85
EBITDA/Assets	-0.17	0.47	-4.09	3.06	7.15

This data demonstrates that IVC-backed firms are on average approximately twice as large as CVC-backed firms. This can be explained by the fact that CVC seems more desirable for early-stage projects while IVC appears favourable for later stage projects (Fulghieri & Seviril, 2009). Fulghieri and Seviril (2009) provide evidence that CVCs benefit more from the relationship in early stages as they can avert competition from exercising effort and protect their research incentives better. This is however contrary to the results from Bider and Gigante (2021) who reason that the further down the investment cycle, the higher the possibility that

[1] Total assets are reported in millions in tables 1, 2, 3 & 4 for improved readability. The original total assets retrieved from Orbis are reported in thousands. Standard deviations have been recalculated accordingly.

the technology is developed and validated and the more easily the technology is translated to useful patent output. Therefore, they argue that CVC investments are more desirable in later stages. Research in the US by Chemmanur et al. (2014) confirms that CVC-backed firms are slightly larger compared to IVC firms. Differences in competitiveness between specific markets could also play a role in the choice of timing of the investment, where we often observe earlier investments in highly competitive markets (Fulghieri & Seviril, 2009). Another factor could be the different structures within CVC funds. Asel et al. (2020) distinguish between external and internal CVC funds, where internal CVC funds invest directly from their own balance sheet and external funds invest from a separate venture fund with fixed corporate funding. Internal funds are said to invest in businesses closer to their core business, while external CVCs are said to be more autonomous and explorative of new business areas. Interviews with CVC funds in this research show that internal CVC funds prefer to invest in later stages when the partnership and strategic benefits are proven, whereas external funds tend to exhibit higher interest in earlier stage investments in businesses that extend or threaten their core business (Asel et al., 2020).

Furthermore, CVC-backed firms tend to be less profitable in terms of ROA and EBITDA, in line with US research. This confirms the theory that IVCs are more financially focused whether CVCs prioritize strategic objectives (Deck, 2008). As average R&D expense per industry of the IVC sample is used for CVCs, their R&D expenses are similar. However, as CVCs have smaller total assets, R&D over total assets is smaller for IVC firms than for CVC firms. Prior research in the US confirms that CVC-backed firms on average have higher R&D spending (Chemmanur et al., 2014). Finally, as presented earlier, there is a wide variety in industry type between the treatment group of CVC-backed firms and the control group of IVC-backed firms. After the PSM, both the treatment and control group have almost identical density plots for the industry and the log total assets variables, hence reducing the bias in treatment effect as well as increasing the validity of causal inference of our CVC-backing dummy (see figures 1 and 2 in the appendix). As the PSM reduces the IVC sample from 991 to 98, the averages of the other firm characteristics have slightly changed as well. The previous observations that CVC-backed firms are less profitable and spend more on R&D still hold. The exact new numbers can be found in tables 3 and 4.

Table 3:Post-Matching IVC Sample Characteristic (n=98)

Variable	mean	sd	min	max	range
ROA %	-6.89	22.81	-98.10	96.50	194.60
Total Assets (million)	316.11	676.81	0.02087	7850.65	7850.63
R&D /Assets	0.20	1.56	0.00	30.13	30.13
EBITDA /Assets	0.03	0.97	-12.63	18.23	30.86
Granted Patents	0.23	1.07	0.00	20.00	20.00
Citations / Patent (ex. self-citations)	6.72	3.75	0.67	25.50	24.83
Citations / Patent	12.58	14.41	0.67	110.00	109.33

Table 4: Post-Matching CVC Sample Characteristic (n=98)

Variable	mean	sd	min	max	range
ROA %	-13.82	28.27	-98.99	90.57	189.56
Total Assets (million)	336.79	714.26	0.03027	9085.43	9085.40
R&D /Assets	4.08	36.26	0.00	709.85	709.85
EBITDA /Assets	-0.08	0.64	-4.95	3.55	8.50
Granted Patents	0.50	2.11	0.00	27.00	27.00
Citations / Patent (ex. self-citations)	7.11	6.28	1.00	82.00	81.00
Citations / Patent	15.82	21.78	1.00	143.40	142.40

We also take a first glance at the patent count data. This reveals that CVC-backed firms have produced 1027 patents in total over the 20 years, while IVC-backed firms have only produced 474 patents. CVC funds have both more firms that produce at least one patent as well as firms that produce a higher number of patents in total, with a max of 27 per year compared to a max of 20 per year for IVC-backed firms (see tables 3 and 4). Next, we compare our patent observations in Europe and the patent observations in previous research in the USA. Firms backed by US-based funds produce more patents than firms backed by EU-based funds, while having a similar number of citations per patent. Our EU sample shows an average of 0.37 patents per firm with 6.92 citations per patent, CVCs and IVCs combined. The average firm in Lenox and Dushnitsky’s (2005) research, which includes all industries, gets granted 13.5 patents per year and gets cited 7 times per patent. Dubocage and Shuwaik’s (2022) study on the biotech industry presents a sample mean of 2.86 patents per firm and 5.97 citations per patent. Chemmanur et al. (2014) show an average of 2.48 patents per firm with 2.28 citations per patent. The quantity of innovation seems therefore larger in the USA, while the quality seems equal. These differences in firm characteristics between CVCs and IVCs and between Europe and the USA will help us interpret the regression output in the next section.

6.2 Regression Findings

6.2.1 Patent count

The objective of our paper is to compare the innovation output of CVC-backed firms versus IVC-backed firms in Europe. We distinguish between innovation quantity and quality. Our first hypotheses to be tested are related to innovation quantity and are as follows:

H1.0: There is no difference in the total number of patents generated by European listed companies backed by CVCs in comparison to those backed by IVCs in the period under consideration (2000-2020).

H1.1: The total number of patents generated by CVC-backed companies is higher than for IVC-backed firms in Europe in the period under consideration (2000-2020), implying CVCs better nurture innovation.

H1.2: The total number of patents generated by IVC-backed firms is higher than for CVC-backed firms in Europe in the period under consideration (2000-2020), implying IVCs better nurture innovation.

We start by examining the baseline regression of the log of granted patents on the CVC dummy to get a general idea of the potential causal relationship between CVC investment and innovation. We are aware this contains a large omitted variable bias. This regression produces a significant and positive coefficient (7.9% with a p-value smaller than 0.01) for the CVC dummy, indicating there could be a relationship between the two variables. Next, we ran the same regression, but added the control variables and robust errors. This regression indicates a similar significant relationship at the 1% significance level and a higher coefficient of 12.6%. This implies we can reject our null-hypothesis and accept our alternative hypothesis 1.1. However, as we use panel data, we want to control for unobservable time invariant differences between the firms and changes over time. Hence, we run a linear panel regression with fixed effects for industry and time and robust errors. The coefficient for the CVC-backing variable is positive and indicates that on average CVC-backed firms generate 10.8% more patents than IVC-backed firms per year. The result is significant at the 0.01 level. This leads us to reject our null-hypothesis and accept our alternative hypothesis 1.1. Table 5 displays all results.

Table 5: Patent Count OLS regression without controls (1) and OLS with controls and robust errors (2) and Fixed Effects time & industry and robust errors (3)

	Dependent Variable: Log of Granted Patents		
	OLS (1)	OLS with controls (2)	FE time & industry (3)
CVC	0.079*** (0.013)	0.128*** (0.035)	0.108*** (0.025)
ROA		-0.001* (0.001)	-0.001*** (0.001)
EBITDA/Assets		-0.079* (0.042)	-0.079** (0.038)
R&D/Assets		-0.018** (0.007)	-0.016*** (0.005)
Log(Total Assets)		0.068*** (0.013)	0.061*** (0.014)
C-Manufacturing		0.430*** (0.052)	
G-Wholesale and retail trade		0.182*** (0.049)	
J-Information and communication		0.158*** (0.052)	
K-Financial and insurance activities		-0.034 (0.042)	
M- Professional, scientific and technical activities		0.521*** (0.072)	
N-Administrative and support service activities		0.446* (0.233)	
Q-Human health and social work activities		-0.044 (0.037)	
Constant	0.099*** (0.099)	0.922*** (0.176)	
Observations	4116		
R2	0.008		
Adjusted R2	0.008		
Residual Std. Error	0.429(df=4114)		
F Statistic	34.938** *(df=1;4114)		

*p<0.1; **p<0.05; ***p<0.01

Our data thus demonstrates that CVC-backed firms produce more innovation than IVC-backed firms. The higher experience of IVCs and executive incentive design do not outweigh the advantages of the CVCs already mentioned earlier. A further deep dive in the literature explaining the larger patent count brings forward the reasoning that CVCs are typically associated with large corporations that have a vested interest in maintaining their competitive advantage through innovation. Therefore, they tend to be more focused on generating a larger number of patents to protect their intellectual property and secure their market position (Barney, 1991; Fulghieri & Seviril, 2009). In contrast, IVCs tend to focus more on financial returns and may be less concerned with the number of patents generated by their portfolio companies and rather focus on one unique commercially attractive technology. Secondly, CVCs are often better equipped to provide their portfolio companies with access to resources and expertise that can facilitate the patenting process. For example, CVCs may have established relationships with patent lawyers and other legal experts who can help their portfolio companies navigate the complex patent application process. Additionally, CVCs may provide their portfolio companies with access to specialized facilities, equipment, and research personnel, which can help accelerate the development and patenting of new technologies (Haslanger et al., 2022). Overall, the rationale behind CVC investments, namely achieving strategic benefits such as a window on technology and enhancing innovation in current business lines, provides an open culture for innovation and development, whereas the rationale behind IVC investments, namely maximize financial return, creates a much narrower focus. This results in CVCs being more tolerant to failure, having longer time horizons, and therefore more likely to experiment to find new ways to innovate and extent or complement their current business (Chemmanur et al., 2014).

Next to our significant result for the main variables of interest, we also observe significant coefficients in our control variables. The log of total assets is positively related with the log of granted patents, which confirms existent research. A larger firm size means more resources and therefore a higher likelihood to invest in innovation. The ROA, EBITDA over total assets and R&D over total assets are all negatively correlated with the log of granted patents. A negative relationship between R&D over total assets and log of granted patents is against common theory and existent literature (Chemmanur et al., 2014; Dushnitsky & Lenox, 2005). However, as R&D was scarcely reported for our sample and as we have used averages for the CVC firms, we do not draw further inferences from this result. The coefficient for ROA over total assets is not in line with previous research by Chemmanur et al. (2014). However, Chemmanur et al. (2014) produces an insignificant coefficient, and our coefficient is very close to zero. The effect of ROA therefore seems unpronounced. We also observe significant coefficients for our industry dummies. Manufacturing, wholesale and retail trade, information and communication, professional, scientific, and technical activities and administrative and support activities are all significant and positively related with patent count. These industries contain amongst others pharmaceutical, chemical, and food related businesses that operate in strong intellectual property regimes. Human health and social work activities and financial and insurance activities on the other hand are negatively related with patent count and operate in weaker intellectual property regimes. However, these coefficients do not explain how the type of industry might impact the CVC's capability in this industry to nurture innovation. Are CVCs able to better nurture innovation in some industries? Previous research in the USA seems to suggest that CVCs are more inclined to create innovation in industries with weak intellectual property as they are better able to benefit from the created technologies. However, as our categories are divided based on the European NACE framework, rather than on strength of IP protection, there may be overlap in IP regimes between our industry variables and therefore we do not make further inferences on industry.

Our results extend the study by Bider and Gigante (2021) by outlining that CVC investments in Europe do not only benefit the parent firm but also positively impact their ventures. Additionally, our results support most prior research conducted in the US (Alvarez-Garrido & Dushnitsky, 2016; Chemmanur et al., 2014; Dubocage & Shuwaikh, 2022; Park & Steensma, 2013). Our analysis on all public firms in Europe backed by a CVC firm between 1990 and 2022 infer that there exists a positive relationship between CVC-backing and innovation of their portfolio firms in Europe. Differences can be found in the magnitude of the results. Overall, it seems that the size of the CVC effect on innovation is larger in the USA. Chemmanur et al. (2014) reported 26.9% more patents pre-IPO and 44.9% more post-IPO, which is higher than our 10.8%. The methodology of this research differs from our research as it measures innovation three years pre and four years post IPO. Theory explains that the post-IPO measure is less reliable, as external investors such as IVCs and CVCs play a smaller role in overseeing public firms compared to their private investees (Steensma & Park, 2013). Therefore, the influence of a CVC on the firm and the innovation of the firm could potentially be diluted after going public. In addition, Aghion et al. (2013) show a positive relationship between publicly traded companies and innovation, as they are able to divide the risk across a large number of investors. However, managerial agency problems could lessen this advantage. Both these arguments might have resulted in this relatively high post-IPO coefficient. Our results, however, are also mostly based on post IPO observations as R studio drops the observations that include non-available datapoints from our regression. Our lower variable, nevertheless, could be explained by the fact that we measure firms over 20 years, and innovation probably decreases to a lower constant over time. Chemmanur et al.'s (2014) post-IPO variable only measures four years.

The difference in strength of the results could also potentially be caused by the fact that CVCs have existed for a longer time period in the USA and therefore have accumulated more experience and established a higher reputation compared to CVCs in Europe. Park and Steensma (2013) show that the impact on innovation is higher when the CVC is more reputable. Park and Steensma (2013) reported themselves a 116% increase in patents over the three years after the last investment compared to IVC. This research does not apply propensity score matching and reveals that the pre-funding rates of CVCs are higher in compared to IVCs. Therefore, they show that the superior rates of innovation in ventures partially stems from the superior selection effort rather than only the superior nurturing effect. This could partially explain the higher results compared to our outcome. The higher coefficients could again also be a result of the higher experience of CVCs in the USA compared to Europe. In addition, as mentioned earlier, the USA has more growth capital available, therefore enabling them to better support their companies along the way, leading to higher quantities of innovation.

Alvarez-Garrido and Dushnitsky (2016) also report that CVC-backed firms produce more patents, on average 2.8 more per year than IVC-backed firms, in other words innovation more than doubles. This research is limited to the biotechnology industry, which is a patent intense industry. The strong effect of CVC on innovation in this sector therefore contradicts Lenox and Dushnitsky's (2005) research which provides evidence that the relationship between innovation and CVC investment is driven by industries with low intellectual property regimes. Lastly, Dubocage and Shuwaikh (2022) show that CVC-backed firms produce on average 8.8% more patents, which is closer to our results. Next to experience, reputation, and industry, other factors mentioned in existent literature that could enhance the CVC effect are geographical proximity, close technological fit, complementary resources, and absorptive capacity (Alvarez-Garrido & Dushnitsky, 2016; Dubocage and Shuwaikh, 2022; Steensma & Park, 2013). More research is necessary to pinpoint the exact mechanisms behind the CVC-effect in Europe.

In short, differences in venture capital environment between the EU and the USA, such as culture, structure, and investment strategy, do not seem to affect the direction of the results.

Our results verify that CVCs in Europe are better at nurturing innovation in start-ups compared to IVCs in Europe. However, the magnitude of the effect is larger in the USA.

6.2.1 Patent Citations

Next to innovation quantity, we present our findings on innovation quality. Our hypotheses to be tested are:

H2.0: There is no difference in the total number of citations generated by European listed companies backed by IVCs in comparison to those backed by CVCs in the period under consideration (2000-2020).

H2.1: The total number of citations per patent generated by CVC-backed companies is higher than for IVC-backed firms in Europe in the period under consideration (2000-2020), implying CVCs enhance innovation quality.

H2.2: The total number of citations per patent generated by IVC-backed firms is higher than for CVC-backed firms under consideration (2000-2020), implying IVCs enhance innovation quality.

As explained, we measure citations excluding self-citations for our dependent variable but execute a robustness check using citations including self-citations. All results with citations per patent (excluding self-citations) as dependent variable are summarised in table. The results for our robustness check can be retrieved in table 1 our appendix. Our first baseline regression with citations per patent regressed on the CVC dummy, presents a very small negative and non-significant result. Adding the control variables results in a similar negative but significant result, with a coefficient of 19.1% and a significance level of 1%. The fixed effects model with both fixed effects for industry and time indicates that patents of CVC-backed IPO firms get cited 20% less than patents of IVC-backed firms. The same results are found for our robustness check. For citations including self-citations, we find that CVC-backed firms receive 19% less citations per patent than IVC-backed firms. Both are significant at the 1% level. Our results therefore provide evidence that IVC-backed companies produce higher quality innovation than CVC-backed companies within Europe.

Table 6: Citations per Patent (excl. self-citations) OLS regression without controls (1), OLS with controls and robust errors (2) and Fixed Effects time & industry and robust errors (3)

	Dependent Variable: Log of Citations Per Patent (excl. self-citations)		
	OLS (1)	OLS with controls (2)	FE time & industry (3)
CVC	-0.001 (0.054)	-0.191** (0.085)	-0.195*** (0.040)
ROA		0.002 (0.002)	0.002*** (0.0004)
EBITDA/Assets		-0.246*** (0.094)	-0.209*** (0.017)
R&D/Assets		-0.055 (0.075)	-0.048 (0.096)
Log(Total Assets)		-0.032 (0.032)	-0.038 (0.039)
C-Manufacturing		-0.201 (0.152)	
G-Wholesale and retail trade		-0.373* (0.225)	
J-Information and communication		-0.376** (0.161)	
M-Professional, scientific, and technical activities		-0.012 (0.163)	
N-Administrative and support service activities		-0.438* (0.257)	
Constant	1.767*** (0.042)	2.469*** (0.498)	
Observations	490		
R2	0.0000		
Adjusted R2	-0.002		
Residual Std. Error	0.574(df=488)		
F Statistic	0.0004(df=1;488)		

*p<0.1; **p<0.05; ***p<0.01

The higher tolerance for failure, longer time horizons, and complementary assets of CVCs seem to have minor effect on patent quality, as IVCs outperform CVCs. To build on our previous arguments, the lower patent quality could potentially also be explained by the fact that CVCs are more focused on protecting their parent company's intellectual property rather than generating technologies that are of broad interest to the scientific community. Additionally, CVC-backed companies may be more constrained in terms of their ability to collaborate with other external partners, as competitors might be hesitant to work with a venture that is linked to their opponent. This can limit their access to new ideas and expertise that can enhance the quality of their patents (Park & Steensma, 2013). IVC-backed companies, on the other hand, may be more focused on generating technologies that are commercially viable and have broad applicability, which can result in patents that are of higher quality, as measured by citations per patent, as well as greater financial returns for the IVC. IVCs may also be more likely to collaborate with external partners, such as universities and research institutions, which can enhance the quality and novelty of the technologies developed by their portfolio companies.

This negative relationship between patent quality and CVC-backing is contrasting to previous findings in the US (Chemmanur et al., 2014; Dubocage & Shuwaikh, 2022; Lenox & Dushnitsky, 2005). Chemmanur et al. (2014) found that CVC-backed firms receive 17.6% more citations per patent pre-IPO than IVCs and 13.2% more citations per patent post-IPO. Dubocage and Shuwaikh (2022) found that CVC-backed firms on average receive 11.5% more citations per patent than IVC-backed firms. Dushnitsky & Lenox (2005) provide evidence that larger CVC investments are related with higher quality patent output, that the positive effect is partially driven by CVC investments in industries that have a weak intellectual property regime, and lastly that the positive effect is magnified for firms with a larger absorptive capacity. The discrepancy between our results and previous literature suggests that there are geographical differences in the quality of innovation resulting from CVC and IVC-backing. The results provide a novel finding for the European venture capital ecosystem and show that patent quality and quantity have different nurturing needs.

Looking back at the firm characteristics, we observed that the corporate investors in the US on average invest in larger firms than non-corporate investors in the US, whereas in Europe we observe the opposite. Investments by CVCs in smaller firms are likely related to smaller investment amounts. Dushnitsky & Lenox (2005) demonstrate that the size of the investment is related to the magnitude of the patent quality. Thus, this suggests that CVCs in the USA make larger investments in general, leading too superior quality innovation. As mentioned earlier, the USA on average has larger fund sizes than Europe, which confirms this theory.

Another driver of the difference in results could be cultural differences between the corporate environment in Europe and the USA. Research has shown that various governance factors, such as board characteristic, CEO compensation, and institutional ownership characteristics are also of great importance to achieve innovation and strategic goals (Anokhin et al., 2016). Hirshleifer et al. (2012) find that overconfident CEOs invest more in research, receive more patents as well as more citations per patent. They are better at exploiting innovative growth opportunities. Differences in governance factors, culture, and management styles between Europe and the USA potentially affect innovation and therefore lead to different innovation quality outcomes.

Chemmanur et al. (2014) furthermore shows that a strong technological fit drives the positive relationship between CVC-backing and innovation quality up. Additionally, they explain that for companies without technological fit, the disadvantages of CVCs, such as decentralized resource allocation and misaligned interest, may overshadow their benefits, making IVCs the preferred partner. Dushnitsky & Lenox (2005) add nuance this story by explaining that a technological fit is indeed necessary for start-ups to benefit from the knowledge of their corporate investor, however, a too close fit reduces the learning curve and negatively impacts innovation. It could be argued that as CVCs in Europe are less risk-taking, amongst others as a result of the culture and compensation scheme, they stick too close to their core business and thereby reduce the novelty and quality of the patents. However, empirical research is necessary to prove this.

Furthermore, Dushnitsky and Lenox (2005) show that a well-developed internal research unit is necessary to effectively learn via CVC-investments. As the CVC environment in Europe is much younger than in the USA, CVCs and their parent firms might not have reached their optimal strategy yet, therefore being less able to create synergies and high quality innovation. Finally, Park and Steensma (2013) show that the reputation of CVCs is positively related to patent quality. Reputation is often built over time and with experience. As CVCs in the US have been around longer and are more experienced, this could potentially explain why CVCs outperform IVCs in the USA, but have a negative effect in Europe. However, more research is necessary behind the drivers of the results in Europe and the exact differences in venture capital environment.

Overall, our study underscores the importance of considering both the quantity and quality of innovation when evaluating the effectiveness of CVC and IVC-backing for IPO companies in Europe. The different motivations and resources provided by CVCs and IVCs lead to differences in the quantity and quality of patents generated by their portfolio companies. Our data provides evidence that CVC-backed companies in general produce more patents, but IVC-backed companies produce patents that are of higher quality and have a greater impact on the scientific community.

7. Discussion

In this section, we will discuss the implications of our results obtained from the PSM and OLS regression in more detail. Moreover, we will point out the limitations of our study and recommendations for future research. Overall, this section aims to provide a comprehensive and insightful discussion of the implications of our findings and the implications for various stakeholders in the industry such as policy makers, academics and the venture capital industry.

7.1 Practical & Theoretical Implications

From the analysis, it is evident that CVCs do in fact aid in the performance innovation of their respective portfolio companies within Europe, although the quality appears not to be as high as that seen from IVC-backed companies. However, the practical implication of these findings is unclear and needs to be discussed further in respect to entrepreneurial firms, the venture capital ecosystem, innovation research as well as economic policy. In Europe, the trend of seeking out CVC funding appears to already be on the rise. According to a report by the European Investment Fund, CVC investments in Europe have increased significantly in recent years, from 1.0bn EUR (160 deals) in 2013 to 4.7bn EUR (468 deals) in 2019 (The European Investment Fund, 2019). This suggests that CVCs are already becoming an increasingly important source of funding for start-ups in Europe, particularly in industries such as biotech, software, and fintech. Our analysis provides valuable insights into the direction of CVCs and their potential impact in Europe moving forward.

The first implication of our findings in Europe is in future investor strategies. Large corporate firms may increase their investments into CVC branches now that the value to both the parent firm as well as the portfolio firm has been recognized. At the same time, IVCs and CVCs in Europe may seek to partner to increase their chances of success by capturing both quantity and quality in terms of innovation for their portfolio firms. This partnership can provide IVCs with access to the resources and expertise of established corporations, while the corporations can benefit from the innovation and growth potential of early-stage companies. Research has shown that such partnerships can be beneficial for both parties, as long as there is a clear understanding of each other's goals and objectives (Gargiulo & Gulati, 1999). However, the increasing competition between CVCs and IVCs may also lead to potential conflicts. For example, CVCs may have access to greater resources and industry knowledge, giving them an advantage over IVCs. On the other hand, IVCs may be more agile and able to move quickly, giving them an advantage in terms of identifying and investing in promising start-ups.

The second implication of our findings relates to industry impact. The increased focus on the quantity of innovation in CVCs may lead to more breakthroughs in industries that are traditionally slower to innovate. Several studies have shown that CVCs are becoming more active in industries that historically have shown a slower rate of innovation, such as healthcare and energy. For example, a study by Henderson (2009) found that CVCs are investing heavily in healthcare start-ups, particularly those that are developing innovative technologies related to personalized medicine, drug discovery, and medical devices. Similarly, a study by Hegeman and Sørheim (2021) found that CVCs are playing an increasingly important role in sustainability, particularly in funding cleantech start-ups. In the US, the impact of CVCs on industry innovation can be seen in the case of Tesla, which received early-stage funding from several CVCs such as Toyota Ventures. Tesla's innovative technologies and business model disrupted the automotive industry, leading to increased competition and a shift towards electric vehicles. This example illustrates how CVCs can have a significant impact on industry innovation by providing start-ups with the resources and support needed to develop and commercialize innovative technologies. Hence, it is likely that we will see CVCs create new markets and address critical global challenges in Europe in the future as well.

The third main implication is in relation to entrepreneurs. The higher number of patents generated by CVC-backed firms suggests that these firms are in general more innovative than their IVC-backed counterparts despite the quality of this innovation not being as high. This perceived advantage of a higher quantity of innovation nurturing from CVC investors may lead future entrepreneurs in Europe to prefer seeking CVC funding over IVC funding in particular industries. The quality of innovation cannot be neglected in any industry, however, there are particular industries which tend to focus more on the quantity than the quality such as consumer electronics where companies strive to introduce new features, models and iterations frequently to stay ahead of competition. Studies have shown that patents are an important indicator of a firm's potential to generate future revenues (Griliches, 1990). Having a larger number of patents can signal to potential investors and partners that a firm is more innovative, and thus, more likely to succeed. Furthermore, start-ups with a larger number of patents may be more attractive to buyers or acquirers, leading to better exit opportunities such as IPOs. According to a study by Statista Research Department (2022), the average amount raised in U.S. IPOs in 2021 was $177 million. Companies that go public also experience faster growth than comparable privately held firms, a rise in the company's public profile and brand recognition and gaining an alternative source of financing (Pagano et al., naha1998). This in turn can enable more innovation and patent generation, hence creating a positive vicious cycle. Finally, CVC investors provide start-ups with access to resources and networks that may not be available through IVC investors alone, which can facilitate the development and commercialization of innovative ideas (Bertoni, Colombo & Grilli, 2013). The perceived advantage of higher innovation nurturing from CVC investors, along with the potential benefits of a larger number of patents, may lead to increased competition for CVC investments among entrepreneurs. This increased competition may result in higher valuations for start-ups that receive CVC funding, making it an attractive option for entrepreneurs seeking funding for their ventures. However, entrepreneurial firms seeking to prioritize the quality of their innovation and its impact may consider pursuing IVC funding or a syndication of both. Companies with high tendencies to focus on the impact of innovation include biotech and pharmaceutical companies. Long development cycles that can span many years, strict standards set by government agencies such as the European Medicines Agency (EMA), and reputational considerations necessitate that firms in these industries focus heavily on the quality of their innovation to maximise their chances of success and increase their credibility.

The final implication is in relation to economic policy. Our findings for economic policy in Europe are twofold. First, policymakers should recognize the value of both quantity and quality of innovation in fostering economic growth and competitiveness. While CVC-backed companies contribute to the overall patent count, IVC-backed companies' higher quality innovation, as indicated by citations per patent, has the potential to drive greater economic impact. Second, policymakers should consider the distribution of funding and support mechanisms to foster a balanced ecosystem. Recognizing the distinct advantages of CVCs and IVCs, policymakers can create policies that promote collaboration and knowledge exchange between these two types of investors. By leveraging the resources and networks of CVCs and the external knowledge and long-term growth focus of IVCs, policymakers can create an environment conducive to both high-quality and high-quantity innovation within Europe. As presented earlier in the paper, the UK and France have well-developed CVC ecosystems and their experiences could serve as learnings for policymakers in other parts of Europe.

7.2 Limitations

Our paper has contributed to the emerging body of literature exploring the relationship between corporate venture capital and their ability to better nurture innovation as well as the implications arising from these new insights. However, we recognize a few shortcomings in our research mainly as a result of the nature of this field. Venture capital is a form of private equity, where, unlike the public market, information is often private. Venture capitalists are often exempted to disclose much information to regulators, which has led to a lack of reliable industry data. This shortage of comprehensive datasets creates challenges for academic research.

Firstly, we have only used firms that IPOed in our research, due to the lack of financial data available on private firms in Europe. We would not be able to control for private firm specific characteristics, such as ROA, EBITDA, R&D, and total assets, inducing the omitted variable bias. This has potentially affected our results as funds might decide to only bring their most innovative firms to the public, leading to a small survivorship bias.

Secondly, there are many gaps in the control data over our 20-year time period. Gaps were mainly found for firms in the years before their IPO. Other reasons for non-existent data we found were when the firm had been dissolved or acquired by another firm and therefore consolidated in the financial statements of the acquiring company. We considered these firms still valuable to our research and have kept them in our data sample. Excluding for instance the dissolved firms might lead to additional survivorship bias. Some other firms had rather unexplainable gaps, which we perceived as randomly missing. RStudio automatically deletes the observations with at least one missing value. Consequently, some firms in some years were omitted from the data sample in our regression. This means our outcome is skewed towards the firms with most datapoints available, which mostly are the firms that IPOed early in our timeframe (2000-2020) and therefore had reliable financial data available for all years. The results of this study are therefore mostly applicable for more mature firms. We have looked at the methodology of other research, but the lack of data is a common problem, leading to suboptimal solutions. Chemmanur et al. (2014) only analyse control variables the four years after the IPO to prevent gaps. However, this is not feasible in our paper as the data available in Europe is much smaller than in the US, making the total amount of datapoints too small for significant research.

For our R&D expense control variable for CVC-backed firms, we had a relatively large number of gaps in our 20-year panel data. R&D expense is highly correlated to innovation and therefore important to include as a control variable. Consequently, we have used the average R&D expense per industry of the IVC sample for each firm in the same industry in the CVC sample. We are aware this is not a completely accurate representation of the actual R&D expense by the CVC portfolio firms. According to the theory, CVCs have more capital available to invest in R&D expense, therefore the R&D expense might be slightly understated potentially leading to an upward bias in the patent count. However, this is partially mitigated by dividing R&D by total assets as CVCs have smaller total assets thereby increasing the R&D over total assets variable for the CVC sample.

In terms of our variable patent count, we have already mentioned some small limitations. Using patents is the most prominent way to measure innovation in current innovation literature. However, not all firms have the goal of creating patents and some might even abstain from patenting for competitive reasons. Differences between industries can also be observed where fewer patents do not necessarily mean fewer innovation in the industry. However, most of these issues should be alleviated by our industry control variable and industry fixed effect. In addition, we have also used patent citations, to not only look at the quantity but also the quality of the innovation. Citations are less correlated with industry.

Finally, we cannot determinately rule out the CVCs superior ability to select more innovative ventures. We have used the propensity score matching to imitate the random assignment of IVC and CVC funds to entrepreneurial firms. This is the second-best approach as random assignment is not possible. Our findings from the propensity score matching and regression do suggest that the difference in patent count has been driven by the treatment effect, however, there exist a small possibility that the results include a partial selection effect.

7.3 Recommendations for Further Research

The findings of our paper comparing the patent production and patent quality of CVC-backed companies versus IVC-backed companies have provided valuable insights into the impact of corporate venture capital on innovation in Europe. However, there is still much to be explored in this area, and further research can help to clarify and build upon the findings of this study. This section presents recommendations for future research in this field, identifying key areas where further investigation could contribute to a more comprehensive understanding of the relationship between CVC-backing and innovation. By addressing these gaps in knowledge, researchers can help to inform investment decisions and promote greater innovation in the venture capital industry in Europe.

The first suggestion for further research is to examine the mechanisms in Europe that affect the capacity of CVCs to accelerate innovation. Research on the USA has shown that boundary conditions exist for CVCs to better nurture innovation as well factors that magnify the positive effect. Since we observed differences with the USA in terms of patent quality, but also in the size of the effect on patent quantity, a better understanding of how CVC investments drive patent quantity and quality could improve the practical value of our research. These insights could be used to optimize CVCs' strategy and policy creation.

One of those mechanisms of interest is the technological fit between CVC firms and their portfolio companies. Due to a lack of available data sources, this paper was unable to directly link the CVC investor to the portfolio company. However, examining the technological fit by comparing the industry type of investor and investee would provide valuable insights. Research in the USA has shown that CVC investments are more likely to result in strategic alliances and knowledge-sharing partnerships between the investor and portfolio company than IVC investments, due to the strategic alignment resulting from shared technological capabilities and resources (Dubocage & Shuwaikh, 2022; Gompers & Lerner, 1998). Conversely, CVC investments with poor technological fit can result in lower levels of innovation and market success for the portfolio company, as well as lower returns for the investor. However, this has not be shown in European markets yet. Other interesting mechanisms to research are tolerance for failure, governance factors, and geographic proximity.

A deeper understanding of the relationship between CVC-backing and innovation could also be achieved by distinguishing between internal and external CVC funds, as they could have different strategies. In addition, as CVCs often operate in a syndicate of investors, it would be interesting to look at the interaction effect between CVCs and IVCs. Is there a minimal share of equity required by CVCs to see an impact on innovation and to what extent can synergies be created between IVCs and CVCs?

The fourth area of our research that could be expanded on is examining the investor experience level and reputation of the CVCs and IVCs. Research in the USA has shown that the experience and reputation of venture capitalists can influence the innovation and success of their portfolio firms. Hence, adding a variable for the firm age and reputation of CVC and IVC investors would provide additional insights into how CVCs in Europe outperform IVCs in terms of innovation performance for their portfolio companies.

The last area of our analysis with room for additional research is examining the geographical differences in innovation seen in different countries within Europe. The innovation of CVC-backed firms can differ between countries due to several factors such as differences in institutional and regulatory frameworks, cultural and social norms, availability of financing, and entrepreneurial culture. Institutional and regulatory frameworks can affect the way CVC-backed firms operate in different countries. For instance, variations in tax laws, intellectual property regulations, and labour laws can significantly influence a firm's innovation strategy. Cultural and social norms can also impact innovation in CVC-backed firms. For example, differences in attitude towards risk-taking, entrepreneurship, and collaboration can influence the success of CVC investments. A study by Teppo and Wüstenhagen (2005) found that cultural factors, such as the level of trust and social capital in a society, have a significant impact on the success of CVC investments. Finally, differences in entrepreneurial culture can affect the way CVC-backed firms operate in different countries. For example, the prevalence of a start-up culture and support for entrepreneurship can impact the success of CVC-backed firms. An interesting angle future research could take is examining how innovation of CVC-backed companies varies between these countries and which countries experienced the greatest increase in innovation after CVC investment.

8. Conclusion

This paper provides further understanding of the venture capital ecosystem in Europe when exploring the relationship between venture capital financing and innovation in the context of IPO firms with headquarters in Europe. This paper is the first one to research the specific impact of CVCs on portfolio firms in Europe. The findings provide evidence that CVC-backed IPO firms have a higher level of innovation, as measured by the number of patents, compared to IVC-backed IPO firms in Europe. On average, CVC-backed firms generate 10.8% more patents per year than their counterpart. Moreover, we find that the quality of innovation from CVC financing is 19% less than that provided by IVCs in the form of citations per patent. While we cannot completely rule out the selection effect of CVC firms, our propensity score matching suggests that the treatment effect of CVC financing on innovation is significant. Our findings imply that differences exist between the venture capital environment in Europe and the USA. CVCs in both continents are better at promoting innovation, but CVCs in Europe fall behind in delivering the same quality of innovation. Various mechanisms have been suggested that could drive our findings, but further empirical research is necessary to confirm our reasoning. This result is significant as it provides valuable new insights into the effectiveness of different types of venture capital financing in promoting innovation in European firms. Our results cast new light on the fact that nurturing both quantity and quality of innovation requires different strategies.

References

Aggarwal, R., & Samwick, A. A. (1999). Executive compensation, strategic competition, and relative performance evaluation: Theory and evidence. *The Journal of Finance*, 54(6), 1999–2043. https://doi.org/10.1111/0022-1082.00180

Aghion, P., Van Reenen, J., & Zingales, L. (2013). Innovation and institutional ownership. *The American Economic Review*, 103(1), 277–304. https://doi.org/10.1257/aer.103.1.277

Anokhin, S., Peck, S., & Wincent, J. (2016). Corporate venture capital: The role of governance factors. *Journal of Business Research*, 69(11), 4744–4749. https://doi.org/10.1016/j.jbusres.2016.04.024

Asel, P., Park, H. D., & Velamuri, S. R. (2015). Creating values through corporate venture capital programs: The choice between internal and external fund structures. *The Journal of Private Equity,* 19(1), 63–72. https://doi.org/10.3905/jpe.2015.19.1.063

Allen, J. W., & Phillips, G. M. (2002). Corporate equity ownership, strategic alliances, and product market relationships. *The Journal of Finance,* 55(6), 2791-2815. https://doi.org/10.1111/0022-1082.00307

Allen, S. A., & Hevert, K. T. (2007). Venture capital investing by information technology companies: Did it pay? *Journal of Business Venturing*, 22, 263-282.

Alvarez-Garrido, E., & Dushnitsky, G. (2016). Are entrepreneurial venture's innovation rates sensitive to investor complementary assets? Comparing biotech ventures backed by corporate and independent VCs. *Strategic Management Journal*, 37(5), 819–834.

Bae, Z. T., & Park, J. H. (2018). When are 'sharks' beneficial? Corporate venture capital investment and start-up innovation performance. *Technology Analysis & Strategic Management*, 30(3), 324–336. https://doi.org/10.1080/09537325.2017.1310376

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99-120.

Bekaert, A., Bossche, P., & Ooghe, H. (1989). Venture capital in the U.S.A., Europe and Japan. *Management International Review*, 29(1), 29-45. Doi: https://www.jstor.org/stable/40227913

Benson, D., & Ziedonis, R. H. (2010). Corporate venture capital and the returns to acquiring portfolio companies. *Journal of Financial Economics*, 98(3), 478-499. https://doi.org/10.1016/j.jfineco.2010.07.003

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

Bertoni, F., Colombo, M. G., & Quas, A. (2015). The patterns of venture capital investment in Europe. *Small Business Economics*, 45(3), 543-560. doi:10.1007/s11187-015-9643-7

Bider, G., & Gigante, G. (2021). The effects of corporate venture capital on value creation and innovation of European publicly owned firms. *Corporate Ownership & Control*, 18(4), 117-133. https://doi.org/10.22495/cocv18i4art9

Chemmanur, T. J., Loutskina, E., & Tian, X. (2014). Corporate venture capital, value creation, and innovation. *The Review of Financial Studies*, 27(8), 2434-2473. https://doi.org/10.1093/rfs/hhu033

Chen, H. L., & Chen, Y. C. (2015). Corporate venture capital and strategic fit: An exploratory study. *Journal of Business Research*, 68(6), 1271-1275.

Deck. (2008). Open Business Models: How to Thrive in the New Innovation Landscape by Henry Chesbrough. *Journal of Product Innovation Management*, *25*(4), 406–408. https://doi.org/10.1111/j.1540-5885.2008.00309_1.x

Dubocage, E., & Shuwaikh, F. (2022). Access to the Corporate Investors' Complementary Resources: A Leverage for Innovation in Biotech Venture Capital-Backed Companies. *Technological Forecasting and Social Change*, 175, 121374

Dushnitsky, G., & Lenox, M. J. (2005). When do incumbents learn from entrepreneurial ventures? Corporate venture capital and investing firm innovation rates. *Research Policy*, 34(5), 615-639.

Dushnitsky, & Shapira, Z. B. (2008). Entrepreneurial finance meet organizational reality: comparing investment practices by Corporate and independent venture capitalists. *Academy of Management*, 2008(1), 1-6. https://doi.org/10.5465/ambpp.2008.33641762

Eisenhardt, K. M., Katila, R., & Rosenberger, J. D. (2008). Swimming with sharks: Technology ventures, defense mechanisms and corporate relationships. *Administrative Science Quarterly*, 53(2), 295-332.

European Commission. (April, 2018). VentureEU: €2.1 billion to boost venture capital investment in Europe's innovative start-ups. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/IP_18_2763

European Investment Bank. (2023). Launch of New Fund of Funds to Support European Tech Champions. Retrieved from https://www.eib.org/en/press/all/2023-056-launch-of-new-fund-of-funds-to-support-european-tech-champions

European Private Equity and Venture Capital Association. (2021). European Private Equity Activity Report 2020. Retrieved from https://www.investeurope.eu/media/4004/investing-in-europe_private-equity-activity_2020_invest-europe_final.pdf

Fulghieri, P., & Sevilir, M. (2009). Organization and financing of innovation, and the choice between corporate and independent venture capital. *The Journal of Financial and Quantitative Analysis*, 44(6), 1291-1321. https://doi.org/10.1017/S0022109009990391

Gompers, P.A., & Lerner, J. (1998). The determinant of corporate venture capital success: organizational structure, incentives, and complementarities, *National Bureau of Economic Research*. Working Paper 6725.

Griliches, Z. (1990). Patent statistics as economic indicators: A survey. *Journal of Economic Literature*, 28(4), 1661-1707.

Gulati, R., & Gargiulo, M. (1999). Where do interorganizational networks come from*?. American Journal of Sociology*, 104(5), 1439-1493. https://doi.org/10.1287/stsc.2017.0032.

Hall, B. H., Jaffe, A., & Trajtenberg, M. (2005). Market value and patent citations. *Journal of Economics*, 36(1), 16-38.

Haslanger, P., Lehmann, E. E., & Seitz, N. (2022). The performance effects of corporate venture capital: a meta-analysis. *The Journal of Technology Transfer*, 1-29.

Hegeman, P. D., & Sørheim, R. (2021). Why do they do it? Corporate venture capital investments in cleantech startups. *Journal of Cleaner Production*, 294, 126315.

Henderson, J. (2009). The role of corporate venture capital funds in financing biotechnology and healthcare: differing approaches and performance consequences. *International Journal of Techno entrepreneurship*, 2(1), 29-44.

Hirshleifer, D., Low, A., & Teoh, S. H. (2012). Are overconfident CEOs better innovators?. *The Journal of Finance*, 67(4), 1457-1498.

Hodgson, L. (2023). CVCs claim highest ever share of European VC deals. Retrieved from https://pitchbook.com/news/articles/cvc-participation-european-vc-deals

Kang, J., Lee, S.U., & Park, G. (2018). The double-edged effects of the corporate venture capital unit's structural autonomy on corporate investors' explorative and exploitative innovation. *Journal of Business Research*, 88, 141-149. https://doi.org/10.1016/j.jbusres.2018.01.049

Kogan, L., Papanikolaou, D., Seru, A., & Stoffman, N. (2012). Technological innovation, resource allocation, and growth. *The Quarterly Journal of Economics*, 127(3), 1263-1299.

Kraemer-Eis, H., Botsari, A., Gvetadze, S., Lang, F., & Torfs, W. (2019). European Small Business Finance Outlook: December 2019 (No. 2019/61*). EIF working paper*.

Lerner, J., Sørensen, M., & Stromberg, P. (2011). Private equity and long-run investment: The case of innovation. *The Journal of Finance*, 66(2), 445-477.

Maula, M., & Murray, G. (2017). Corporate venture capital and the creation of US public companies: The impact of sources of venture capital on the performance of portfolio companies. In Creating value: *Winners in the new business environment*, 161-183.

Narin, F., Hamilton, K. S., & Olivastro, D. (1997). The increasing linkage between US technology and public science. *Research policy*, 26(3), 317-330.

Nomaler, Ö., & Verspagen, B. (2008). Knowledge flows, patent citations and the impact of science on technology. *Economic Systems Research*, 20(4), 339-366.

Pagano, M., Panetta, F., & Zingales, L. (1998). Why do companies go public? An empirical analysis. *The Journal of Finance*, 53(1), 27-64.

Park, & Steensma, H. K. (2013). The Selection and Nurturing Effects of Corporate Investors on New Venture Innovativeness. *Strategic Entrepreneurship Journal*, 7(4), 311–330. https://doi.org/10.1002/sej.1165

Pisano, G. P., & Shih, W. C. (2012). Does America really need manufacturing*? Harvard Business Review*, 90(3), 94-102.

Rogier, V. (2003). The epoline® online European patent register. *World Patent Information*, 25(1), 53-56.

Röhm, P., Merz, M., & Kuckertz, A. (2020). Identifying corporate venture capital investors – A data-cleaning procedure. *Finance Research Letters*, 32(C).

Rohrer, D., Spits, J., & Wendt, T. (2022). Harnessing the True Value of Corporate Venture Capital. Bain & Company.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41-55.

Schwarzkopf, C. (2016). Fostering innovation and entrepreneurship: Entrepreneurial ecosystem and entrepreneurial fundamentals in the USA and Germany. In *Fostering Innovation and Entrepreneurship: Entrepreneurial Ecosystem and Entrepreneurial Fundamentals in the USA and Germany.* https://doi.org/10.1007/978-3-658-13512-6

Seru, A. (2014). Firm boundaries matter: Evidence from conglomerates and R&D activity. The *Journal of Finance*, 67(3), 851-881.

Siegel, R., Siegel, E., & MacMillan, I. (1988). Corporate venture capitalists: autonomy, obstacles, and performance. *Journal of Business Venturing*, 3, 233–247.

Statista Research Department (2022). Median IPO size in the U.S. 2005-2021. Retrieved from https://www.statista.com/statistics/251149/median-deal-size-of-ipos-in-the-united-states/

Teppo, T., & Wustenhagen, R. (2009). Why corporate venture capital funds fail - evidence from the European energy industry. *World Review of Entrepreneurship, Management, and Sustainable Development*, *5*(4), 353–375. https://doi.org/10.1504/WREMSD

Appendix

Table 1: IVC-backed firms’ industries pre-matching

Industry	n
A - Agriculture, forestry, and fishing	4
B - Mining and quarrying	11
C - Manufacturing	329
D - Electricity, gas, steam, and air conditioning supply	15
E - Water supply; sewerage, waste management, and remediation activities	3
F - Construction	9
G - Wholesale and retail trade	76
H - Transportation and storage	8
I - Accommodation and food service activities	18
J - Information and communication	195
K - Financial and insurance activities	73
L - Real estate activities	10
M - Professional, scientific, and technical activities	162
N - Administrative and support service activities	38
O - Public administration and defence; compulsory social security	2
P - Education	1
Q - Human health and social work activities	27
R - Arts, entertainment, and recreation	6
S - Other service activities	5

Table 2: CVC-backed firms’ industries pre-matching

Industry	n
B - Mining and quarrying	1
C - Manufacturing	33
G - Wholesale and retail trade	12
J - Information and communication	21
K - Financial and insurance activities	4
M - Professional, scientific, and technical activities	28
N - Administrative and support service activities	2
Q - Human health and social work activities	3

Table 3: IVC-backed firms' industries post-matching

Industry	n
B - Mining and quarrying	1
C - Manufacturing	37
G - Wholesale and retail trade	13
J - Information and communication	21
K - Financial and insurance activities	6
M - Professional, scientific, and technical activities	13
N - Administrative and support service activities	4
Q - Human health and social work activities	3

Table 4: CVC-backed firms' industries post-matching

Industry	n
B - Mining and quarrying	1
C - Manufacturing	33
G - Wholesale and retail trade	11
J - Information and communication	20
K - Financial and insurance activities	3
M - Professional, scientific, and technical activities	26
N - Administrative and support service activities	1
Q - Human health and social work activities	3

Table 5: Mean total assets pre and post-matching

Summary of Balance for All Data:

	Mean Treated	Mean Control	Std. Mean Diff.	Var Ratio
Distance	0.1020	0.1020	0.0294	1.0018
Log Mean Total Assets	10.81924	10.8775	-0.0297	0.9896

Summary of Balance for Matched Data:

	Mean Treated	Mean Control	Std. Mean Diff.	Var Ratio
Distance	0.1020	0.1020	0.0015	1.0082
Log Mean Total Assets	10.81924	10.8223	-0.0015	1.0071

Figure 1: Density plot pre and post-matching by industry

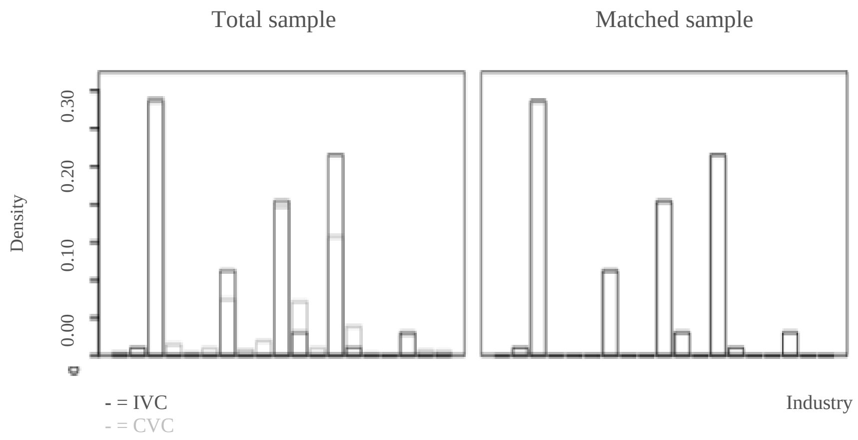


Figure 2: Density plot pre and post-matching by mean log total assets

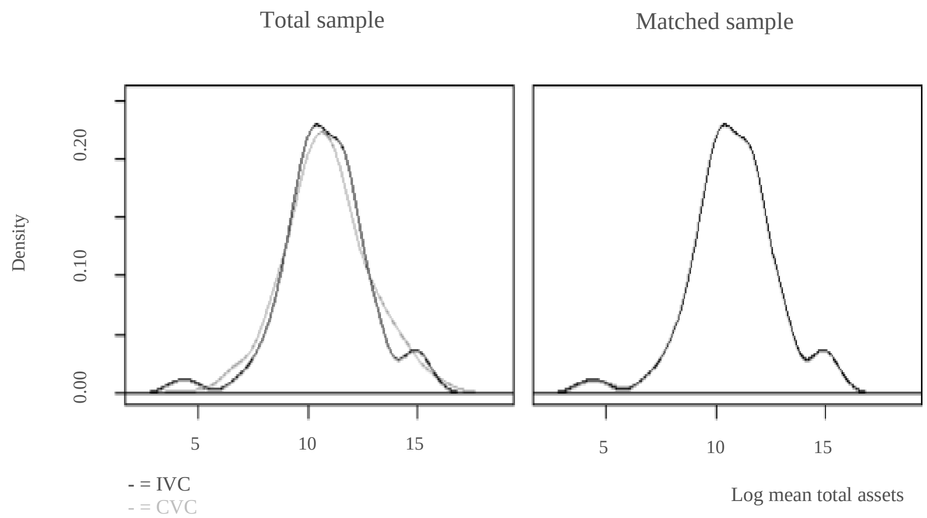


Table 6: IVC average R&D per industry

Industry	Mean R&D (000’s)
B - Mining and quarrying	23453
C - Manufacturing	13645
D - Electricity, gas, steam, and air conditioning supply	39971
E - Water supply; sewerage, waste management and remediation activities	2921
F - Construction	104
G - Wholesale and retail trade	7559
H - Transportation and storage	2822
I - Accommodation and food service activities	5312
J - Information and communication	13126
K - Financial and insurance activities	32564
M - Professional, scientific, and technical activities	21487
N - Administrative and support service activities	2913
O - Public administration and defence; compulsory social security	4090
Q - Human health and social work activities	9480
R - Arts, entertainment, and recreation	24625
S - Other service activities	97

Table 7: Robustness Check – Citations per Patent (incl. self-citations)

	Dependent Variable: Log of Citations Per Patent (incl. self-citations)		
	OLS (1)	OLS with controls (2)	FE industry & time (3)
CVC	0.124 (0.082)	-0.131 (0.122)	-0.192*** (0.070)
ROA		0.002 (0.002)	0.003 (0.002)
EBITDA over Assets		-0.346*** (0.147)	-0.283*** (0.028)
R&D over Assets		-0.373*** (0.109)	-0.322*** (0.104)
Log Total Assets		-0.092* (0.052)	-0.147** (0.062)
C-Manufacturing		-0.113 (0.224)	
G-Wholesale and retail trade		-0.744** (0.307)	
J-Information and communication		-0.282 (0.270)	
M-Professional, scientific, and technical activities		-0.590** (0.257)	
N-Administrative and support service activities		1.308*** (0.392)	
Constant	2.145*** (0.065)	3.496*** (0.792)	
Observations	490		
R2	0.005		
Adjusted R2	0.003		
Residual Std. Error	0.873 (df=488)		
F Statistic	2.300 (df=1;488)		

*p<0.1; **p<0.05; ***p<0.01

Table 8: Hausman Test

Hausman Test
Alternative hypothesis: one model is inconsistent
Asymptotic test statistic: Chi-square = 20.021
With p-value = 0.001239