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# The European venture capital landscape: an EIF perspective

## Volume I:
## The impact of EIF on the VC ecosystem

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## Corrigendum

In a previous iteration of this work, we provided an incorrect interpretation of the coefficient $\alpha_2$ for model (1) in section 4.3, which pertains to a conditional effect. All concerned statements and conclusion are thus retracted, and the correct interpretation is discussed in this reprint.

This result, however, was not essential to support the main conclusion of our study, which remains largely unaffected. The authors wish to apologise for any inconvenience caused.

# Preface

The European Investment Fund (EIF) is a specialist provider of risk finance to benefit small and medium-sized enterprises (SME) across Europe. By developing and offering targeted financial products to our intermediaries, such as banks, guarantee and leasing companies, micro-credit providers and private equity funds, we enhance SMEs access to finance.

EIF is a leading institution in the European venture capital market. We focus on the establishment of a sustainable venture capital Ecosystem in Europe supporting innovation and entrepreneurship. We concentrate on building the necessary private sector venture capital infrastructure to address market gaps and opportunities with the aim to further enhance the attractiveness of European venture capital as an alternative asset class.

How do we achieve this? We work with venture capital funds - acting as our intermediaries - that invest into innovative high-tech SMEs in their early and growth phases. We focus particularly on disruptive early-stage technology enterprises which typically face financing challenges but also provide outstanding investment opportunities. We have built a strong expertise in the Life Sciences, Cleantech and ICT sectors and in setting-up, managing or advising tailored Fund-of-Funds, mostly with resources entrusted to us by third parties such as the European Investment Bank, the European Commission, national and regional authorities.

For us, not only volumes matter, but the real effects of our support – effects on the market and in particular on the – so called – final beneficiaries, the SMEs. Against this background, we are happy to start with the present publication a sub-series within the regular EIF Working Papers dedicated to this topic – the analysis of the effects of EIF's VC activities. The work is based on an ongoing project, run by the Research & Market Analysis team, and is to be seen in the wider context of EIF's ambition to properly assess the impact of its activities.

Impact analyses in the field of SME guarantees and basic groundwork in the area of microfinance have already been published (see EIF Working Papers 2015/029 and 2016/033). This first paper regarding venture capital investigates EIF's ability to effectively crowd-in VC financing. Moreover, it provides an introduction to our activities, covering the first 20 years of our VC business. Finally, it sets the framework for further analyses and publications, leading over time to a thorough impact assessment at SME level.

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## Non-technical Summary†

In the past 20 years, the European Investment Fund (EIF, the Fund) has been the leading public provider of risk capital, and in particular of venture capital (VC), to young and innovative European startups. VC is an essential source for startups to achieve growth and create value through innovation, and although it should not be seen as a substitute to traditional banking finance (since it serves only a specific and restricted class of firms), research has shown that the innovativeness, productivity and development of the overall economy reap the returns of a thriving venture capital ecosystem.

EIF's established reputation in the European VC market is substantiated by its significant role in European investment and fundraising activity. In this paper we estimate that the investment activity backed by EIF represented 41% of total investments in Europe in 2014 (29% in 2007). The share directly attributable to EIF amounts to 10% (5% in 2007), hinting to the significant leverage that characterises EIF-backed investments. Moreover we estimate that fundraising volumes backed by EIF in 2014 amount to 45% of the overall volumes collected by European VC investors (36% in 2007), against a share directly attributable to EIF totalling 12% (5% in 2007).

While the above figures clearly attest EIF's rising significance in the broader European VC landscape, they also confer increased responsibilities towards the VC market and the broader public. On the one hand, EIF is expected to prove that different programmes supporting the European VC market are soundly managed. On the other hand, as these programmes represent public policy interventions, it is essential for EIF to pursue the overarching economic goals set forth by the policy maker.

To address these important arguments, we present the first volume of a series of working papers titled "The European venture capital landscape: an EIF perspective". In this series we tackle the need for additional information on the European VC market, and in particular the segment backed by EIF, by looking at the different measures of performance of technology startups, as well as their characteristics, profiles, and decisions. The goal of this series is twofold: first, to assess the magnitude of the economic effects to which EIF-backed investments contributed. We do so by means of numerous descriptive analyses. Second, to assess whether EIF's intervention in the market significantly affects the performance of the startups it supports, as well as the broader European VC ecosystem.

In this first volume, we address the question on whether EIF activity has effectively crowded-in VC financing. That is, whether other market players have intensified their activity in the aftermath of EIF's increased investments. Prior to this, we outline the economic rationale for EIF VC activities (section 1) and provide an overview of the EIF portfolio of VC investments (section 2). In section 3, we conclude the descriptive part of our work by evaluating the geographical features of the EIF VC portfolio.

To this end, we analyse the geographic distribution of 2,934 EIF-backed startups in the seed and start-up stage, invested over the 1996-2014 period. Our data, based on firm-level headquarter's

† This paper benefited from the comments and inputs of many EIF colleagues, for which we are very grateful. In primis, we would like to acknowledge the invaluable help of our Research & Market Analysis colleagues: Salome Gvetadze, Frank Lang and Wouter Torfs. Moreover, we would like to express our gratitude to Ulrich Grabenwarter and Frank Vancamelbecke, for their comments and support. Special thanks also go to Cornelius Mueller and Julien Krantz — from Invest Europe research — and Prof. Thomas Hellmann, from University of Oxford, Saïd Business School. All errors are attributable to the authors.

locations, provides a number of interesting results. In particular, we notice a significant degree of geographic concentration in a few key areas, a finding that we assume to reflect the features of the broader European VC market. For this reason, we focus on identifying key locations (*i.e.* hubs) attracting the largest share of EIF-backed investments. This results in a list of 20 European cities that have collectively attracted about 40% of all EIF-backed investments until 2014. Remarkably, the top 20 hubs also originated 83% of all invested amounts in the same period. In this respect, the evidence suggests that EIF investments contributed to the rise of new areas of intense venture capital activity.

By tracing the investment channels across the elicited hubs, we highlight an intricate network of mutual investment exchanges, which is particular dense in more mature hubs. We find that European hubs, and in particular those backed by EIF investments, act as the beating heart of a complex network of national and international investments. Such claim is supported by data on investment amounts originated by hubs: 23% of these remains in the hub, 40% reaches out to other in-country locations and the remaining 37% travels beyond the national frontier. Since higher cross-border investments can be interpreted as signal of deeper integration of the European VC market, we conclude that EIF may hold a vantage point in fostering the consolidation of a European-wide VC ecosystem.

In section 4, we investigate the dynamic effects of EIF activities on the European venture capital ecosystem. We test the presence of EIF additionality on the VC market developments by using data on VC investment amounts aggregated at regional NUTS-2 level. The information on regional VC investment levels for EIF and the overall VC market is retrieved from, respectively, the EIF proprietary database and Invest Europe. This data is then augmented with region-specific economic, social and geographic variables from Eurostat. We obtain a panel dataset in which 223 NUTS-2 regions are observed from 2007 to 2014. We use this data to estimate a dynamic econometric model in which endogeneity issues (*e.g.* the fact that EIF investments and overall market activity simultaneously affect each other) are addressed by the appropriate model design.

Overall, the data rule out the ”crowding-out” argument for EIF investments. Instead, we observe a positive and statistically significant average effect of the EIF funding, affecting VC amounts invested in subsequent years. The finding gives preliminary proof towards EIF effective crowding-in of VC capital (both from EIF co-investors and non-EIF co-investors) in the analysed period. Our estimates show that, on average, a 1% increase in EIF-provided VC capital in a region led to a 0.89% increase in other investors' activity in the same region, three years later. Moreover, in some specifications of our model, we find that the positive effect of the EIF activities is bigger in regions with lower levels of educational achievement. Since higher educational levels are associated to higher VC investments, our finding hints that the catalytic effect of the Fund may be stronger in geographic areas characterised by less developed venture capital markets.

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# 1 Economic rationale of EIF's activities in the EU VC market[1]

In 1992 the European Council urged the establishment of a European Investment Fund (EIF, the Fund) in order to promote economic recovery in Europe. As a reaction, the EIF was established as a public-private-partnership by its Constitutive General Meeting (14th June 1994). The Fund started with Trans-European Network infrastructure transactions and guarantee operations in support of SMEs. Later-on EIF commenced as well venture capital (VC) activities.[2] Together with own funds, EIF invests resources managed on behalf of capital providers under a range of programmes; it also manages and advises funds-of-funds and initiatives for third party investors.

The relevance of venture capital financing, not only for young and innovative companies but also for the economy as a whole, ranks high in the toolbox of policy recommendations (see *e.g.* Tykvová *et al.*, 2012; Frontier Economics, 2013). However, there are impediments to a development of a vibrant European VC market and still the "[p]resence and accessibility of alternative funding avenues is underdeveloped for SMEs, *e.g.* venture capital & angel investing" (AFME and BCG, 2015). Against this background it is one of EIF's key objectives to play a crucial role in establishing a sustainable venture capital ecosystem in Europe.

VC is an essential source for start-up[3] and young companies to achieve growth and create value through innovation. External equity is not to be seen as a substitute for traditional, mainly bank-centred, SME financing instruments. Rather, it serves a specific and restricted group of SMEs (including startups), which, however, may significantly contribute to the innovativeness, productivity and development of the overall economy.

## 1.1 Rationale for public support of VC

What is the economic rationale for public support in this area? We should not go into detail here, but it is worth mentioning some key principles: the justification for public intervention in the area of SME financing in general is based on the fact that market imperfections or failures do not exclusively affect the economy during a deep recession or a financial crisis, but will instead constitute persistent structural issues. There are several factors contributing to market imperfections and failures in the context of SME financing. One of them is the disproportionality between the cost of assessing a relatively small company's need for finance and the potential financial return (problem of high fixed cost). Such issue is further reinforced by asymmetric information (information gap between the potential provider and the potential beneficiary of financing). The availability (and quality) of information about smaller — and often younger — enterprises is typically even worse than for bigger and more mature companies. In particular, start-up companies cannot provide a track record, have no or limited collateral, and often the main assets are the ideas of the entrepreneur - who often holds

[1] Significant parts of this chapter are based on Kraemer-Eis *et al.* (2015).

[2] In June 2000, EIF's shareholders approved a reform of the institution and the EIB became the majority shareholder. Since then, EIB and EIF form the EIB Group with the EIF being the specialist arm for providing risk financing to benefit SMEs. In 2001 the TEN guarantee portfolio has been transferred from EIF to EIB.

[3] Throughout this paper, the terms *startup*, *start-up* and *start-up company* will be used interchangeably.

no proven managerial skills. Combined with uncertainty, this causes agency problems that affect the financing providers' behaviour.[4] This can result in an insufficient supply of private capital (OECD, 2006).

Venture capitalists play a crucial role in removing information asymmetries as intermediaries, through activities of screening, contracting and monitoring and thus being able to assess the quality of small businesses. However, the costs of performing due diligence are significant and it is often more cost effective for investors to concentrate their investing to later-stage companies where better information is available, bigger investments can be made and relative costs are lower. Indeed, over the past years, VC investors became more risk-averse and focussed more on later stage investments (Wilson, 2015b). Hence, economies of scale have deteriorating effects on early stage ventures and their investors.[5]

An additional source of market failures — and a further rationale for government intervention — stems from the existence of positive externalities (also called spillovers). The theory of public finance mentions that public support can be an appropriate response in relation to activities that generate positive externalities (Lerner, 2002). That is, activities whose effects will reach beyond the company, positively affecting other companies and society as a whole. There might be a suboptimal level of innovation if companies are not able to capture the entire surplus of their (R&D) investments. These externalities can lead to insufficient provision of private sector finance to new companies (and innovation). Furthermore, a vibrant VC industry needs an established institutional environment as well as a critical mass of companies and VC investors (for both, not only quantity but also — and in particular — quality is important). These factors only develop over time as the industry grows and matures. Hence, the first movers give rise to positive externalities that benefit future market players. The experience of various countries shows that public support can play an important role as an initiator for a viable VC industry. Such a development, however, takes time (Tykvová *et al.*, 2012).[6]

Moreover, the venture capital ecosystem in Europe still experiences high fragmentation across national borders, as well as systematic issues like, inter alia, the risk of double taxation. Hence, there is not yet a real European VC market, but still an aggregation of several markets. Measures to improve the situation are underway, including the EU's important plan, launched during 2015, to develop a fully functioning Capital Markets Union (CMU) by the end of 2019.[7] However, these issues regarding framework conditions and the enabling environment for companies, as well as demand side problems (*e.g.* cultural differences regarding entrepreneurship and risk taking, treatment of bankruptcies

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[4] See the traditional economic literature related to credit rationing, *e.g.* Akerlof, 1970; Jaffee and Russell, 1976; Stiglitz and Weiss, 1981; Arrow, 1985. Agency theory/the principal-agent approach is often applied in economic literature for analysing relationships between lenders and borrowers (*e.g.* contract design, selection process, credit constraints).

[5] This is why syndication, *i.e.* VC firms' joint investment, is often seen as one solution for information asymmetries in venture capital investing as well as a way of optimizing and diversifying the investment. Also staging the investment can be considered as a risk decreasing measure in an agency and monitoring framework.

[6] See for a detailed discussion of the European VC market performance Kelly (2011) or Lerner (2009).

[7] In addition, the development of the European VC market — that started much later than for example in the US – was severely interrupted by a number of crises (*i.e.* the dot-com crash and the post 2008 financial and economic crisis).

that are often seen as disgrace) can only be indirectly influenced by a supply side actor like EIF, *e.g.* by its pan-European approach, standard setting and spreading of best market practice, advice and consultation.

Overall, the market weaknesses in the area of VC justify government intervention that addresses the shortage of VC supply (Tykvová *et al.*, 2012). An Unquote Intelligence (2006) survey found that "public money remains absolutely critical to the European venture industry and is likely to remain so for the next five years", and this has been particularly true for new funds, as most public funding bodies support first-time funds, while this is true for only approximately half of private investors. Besides the additional funding volumes, public investors' participation in a VC fund can also have a positive signalling effect on private investors, *e.g.* due to perceived strong due diligence requirements and an assumed relatively high stability of public LPs' commitment to a fund. These advantages seem to outweigh the potential disadvantages (*e.g.* a possibly negative impact on speed and responsiveness or imposed restrictions in the investment strategy of the fund) of public investors' participation.

However, much depends on how the public support is provided. The relationship between private VC activities and governmental support was analysed in several empirical studies: according to Colombo *et al.* (2014), the design of a public VC investment scheme is important for their impact. In particular, governmental VC schemes seem to have been more successful when they acted alongside private investors, which would favour a governmental fund-of-funds set-up over direct public investments. Indeed, the focus of support instruments "has shifted from government equity funds investing directly to more indirect models such as co-investments funds and fund-of-funds" in OECD countries (Wilson, 2015b). Moreover, Brander *et al.* (2015), in a continuation of their 2010 study, find that enterprises funded by both governmental VC and private VC obtain more investment than enterprises funded purely by private VCs, and much more than those funded purely by governmental support. There is also a positive association between mixed governmental/private funding and successful exits, as measured by initial public offerings and acquisitions, attributable largely to the additional investment. These findings are in line with Bertoni and Tykvová (2012), who concluded "that syndicates between private and governmental venture capital investors, in which the private investor takes the lead, are the most efficient form in terms of innovation production that outperforms all other forms".[8]

Hence, an efficient policy action to crowd-in private investors, catalyse private sector investment[9] and pursue EIF and European statutory objectives should focus on *1) pan-European-level activities*, in order to support the development of a real European VC market, originated by *2) venture capitalists* (but also business angels and other types of early-stage investors) as market-oriented professionals.

[8] There is a growing literature supporting the view that public policy in the area of venture capital should go beyond an exclusive support of VC funds (see Hellmann *et al.* 2015), but rather aim to attract equity financing to Europe also from alternative sources, such as angel investors and crowdfunding (see Wilson 2015b; see also Aubrey *et al.* 2015, for related policy recommendations to support growth firms). For this reason, EIF has developed over time a wide range of equity products, in addition to its "pure" VC activities, like technology transfer (to support the commercialisation of Universities' research know how) and Lower Mid-Market activities, as well as mezzanine instruments in order to meet increasing market needs in between debt and equity instruments, in particular for companies in special situations (like strong growth phases). Moreover, social entrepreneurship is facilitated via Social Impact Funds activities. Another example is the support of Business Angels – to complement support measures in the VC space and to incentivise alternative investors.

[9] We discussed some guiding principles in Kraemer-Eis *et al.* (2013).

The rationale for this is the pursuit of efficiency, for market participants know best where the needs are and where technological developments are leading to.

Of course it can be argued that a market which, according to latest data from Invest Europe (formerly EVCA), relies to more than 30%[10] on resources from government agencies and public institutions is not "healthy" and that this percentage of public support is unsatisfyingly high on the long term. While one of the overarching objectives of EIF VC activities is indeed the establishment of a self-sustainable, fully-integrated European VC market, the aim of this paper is to challenge the critique of excessive public intervention. We do so by analysing EIF investments in the 2007-2014 period and measuring their impact on the broader European VC ecosystem. The analysis and results are described in section 4.

## 1.2 EIF's business model

EIF's task is to address market gaps and to crowd-in private capital. In the VC space this includes to act as counter-cyclical investor during downturns of the market, but as well to support first-time teams (where the uncertainty for other investors is the highest due to the shortage of track records). Its aim is to stimulate the market, not to make it become dependent on public financing. Even though it manages resources on behalf of public institutions like the European Commission or the European Investment Bank, the EIF pursues publicy policy with a market-oriented strategy, investing *pari-passu* with private investors (*i.e.* on the same terms and conditions) and seeking a positive return. In order to ensure sound investment decisions, based on market developments, the Fund has from inception and deliberately been a public-private partnership teaming up with a broad range of equity market players across Europe. Over the last 20 years EIF has built an extensive network, accumulating substantive market expertise, and established itself as the key public-private European VC investor in Europe. Moreover, it is important to see that many of the commercial VC funds being the pillars and stars of Europe's VC market today would not be there without their development being facilitated by EIF's strong financial but also technical support. Many brand names of today's European VC community have been cornerstoned by EIF investments in their funds.

EIF's activity figures indicate its engagement in the broader European VC market (see section 2.2). However, even though EIF strives to stimulate market activity through its investments, it would not invest into funds which are not majority-financed by private, market-based investors. Every investment opportunity is assessed on the basis of expected financial performance and contribution to policy objectives. At the same time, the Fund has shown to be itself a reliable source of funding throughout the economic cycle and to be able and willing to act as a cornerstone investor where necessary, ready to take a long-term perspective on risk and return. All this, combined with close attention to monitoring and portfolio management aspects, has enabled it to build a strong and enviable reputation in the market.[11]

Besides its cornerstone commitment, EIF provides advice and support at different stages and levels

[10] As of end of 2015.

[11] Also due to the successful backing of, *inter alia*, companies like Skype, Skyscanner, MoneyFarm, Novaled, Spotify, Shazam, Xing, Workable.

to fundraising teams. This ranges from shaping investment strategies, legal and structural issues to contributing to the creation of teams and coordinating their fundraising process, including liasing with potential private investors. Moreover, in the post-investment stage EIF assumes an active role in support of fund managers on matters relating to *e.g.* contractual changes, restructurings, networking.

What are EIF's medium and long term goals? In the coming years, EIF will continue to address market gaps and to stimulate the market when needed, including in the context of the Investment Plan for Europe (often called the Juncker Plan), where venture capital is a key policy focus. Its objective is to be active in the market segments where it can add value, also partnering with other public players like National Public Institutions (NPIs). Once the level of private investment in a certain market has reached a satisfying level, EIF is prepared to decrease its investments, and to pioneer new instruments with market-players who reach beyond "traditional" markets in order to ensure that promising startups will continue to be funded. EIF's aim remains one of developing a self-sustainable European equity market promoting innovation and supporting the most promising SMEs, thereby ensuring Europe's competitiveness at the international level.

## 2 20 years of EIF-backed VC investments

Venture capital investments play a preeminent role in EIF's overall equity activities, typically composing 40 to 60% of all equity volumes committed in a specific year. These commitments, on average amplified fivefold by venture capital investors, turned into EUR 10.94bn venture capital investments in the period 1996-2014. These benefited a "portfolio" of about 3,400 seed and start-up companies, throughout Europe and the World.

The main aim of this research paper is to answer whether the aforementioned EIF activity has effectively crowded-in European VC financing. That is, whether other market players have intensified their activity in the aftermath of EIF's increased investments. Prior to this, we present an exploration into EIF's venture capital activity and its noteworthy effects. To achieve this, we will set aside theories and speculations, focussing exclusively on findings revealed by data.

The paper is organised as follows. Having described the economic rationale of EIF VC activities in section 1, the remainder of this section introduces to the key figures characterising EIF VC activities in the past 20 years, including their significance *vis-a-vis* the broader European VC market. This section concludes by discussing the motivations of our research series, as well as the methodology and data sources we used.

Section 3 provides a geographical analysis of EIF-backed investments, based on the geolocation of targeted start-ups. The aim of section 3 is to identify patterns in the spatial distribution of EIF-backed investments and to conjecture whether any of these also affects the broader VC industry.

In section 4, we revert to the main goal of this paper. By using European investment aggregates at regional level for the 2007-2014 period, we assess whether EIF-backed VC investments acted as an effective catalyst of additional (non-EIF) venture capital financing. Section 5 concludes by introducing further research topics, to be developed in forthcoming issues.

## 2.1 Portfolio trends over time

Our starting point is the EIF VC portfolio: how is it defined, and which features does it display? As described in section 1.2, EIF operates as a fund-of-funds, hence its portfolio of technology companies is indirect in nature, a set of companies receiving EIF-backed venture capital. However, as its dynamics resemble conventional VC firms' portfolios, we can conveniently describe its features in analogous terms.

Along this line of reasoning, start-ups enter the EIF VC portfolio in their *first investment* year. This typically coincides with the start-ups' *seed* or *series A* investment, but need not necessarily be.[12] The equity shares of VC-backed companies will remain in the EIF indirect portfolio until a liquidity event is reached. Note that, if multiple EIF-backed funds have invested into the same company, only the last exit in chronological order will be counted as an "EIF portfolio" exit. This approach allows for a dynamic partitioning of the EIF portfolio over the course of the last 20 years, as shown in Figure 1. In a given year companies in the EIF VC portfolio can be assigned to four distinct groups: *new investments*, depicted in blue, *i.e.* new start-ups invested by an EIF-backed VC fund; *portfolio companies*, depicted in grey, representing prior investments currently retained by EIF-backed funds;[13] *trade sales* and *write-offs*, in yellow and orange respectively, signalling companies exiting the EIF VC portfolio following a positive or negative liquidity event.

As depicted in Figure 1, a first increase in EIF's VC activity took place in the 1999-2000 biennium, following the centralisation of the EIB group's risk capital activities under the management of EIF. Moreover, activities under the ETF Start-up scheme, started in 1998 and funded by the European Union, began progressing at an accelerating pace. The remarkable growth of the EIF VC portfolio in this period reached an abrupt halt in 2001, where the business environment suddenly turned unfavourable, due to the collapse of the high-tech segments of the World's main stock exchanges.

The disturbance of the so-called "dot-com collapse" resonated until late 2004, as testified by the all-time high of write-offs in this period. However, while the magnitude of VC divestments seems rather unimpressive given the typical risk profile of VC startups, hints of a sluggish recovery in the European VC market are further testified by the limited number of new investments in the 2002-2005 period. From then on, a short-lived expansion during the 2006-2007 biennium quickly led to a second negative cycle of economic adverse conditions. But what is perhaps more interesting, is that starting from these years we observe a remarkable growth in trade sales figures, while write-offs seem confined to physiological levels.[14] This could be one of the many aspects, including the revival of the knowledge-based economy brought by *i.a.* the surge in mobile electronics penetration rates, that could be driving the recent convergence to pre-2001 investment figures. Figures that culminated, in 2014, to more than 400 EIF-backed Seed and Start-up companies, a record year to date.[15]

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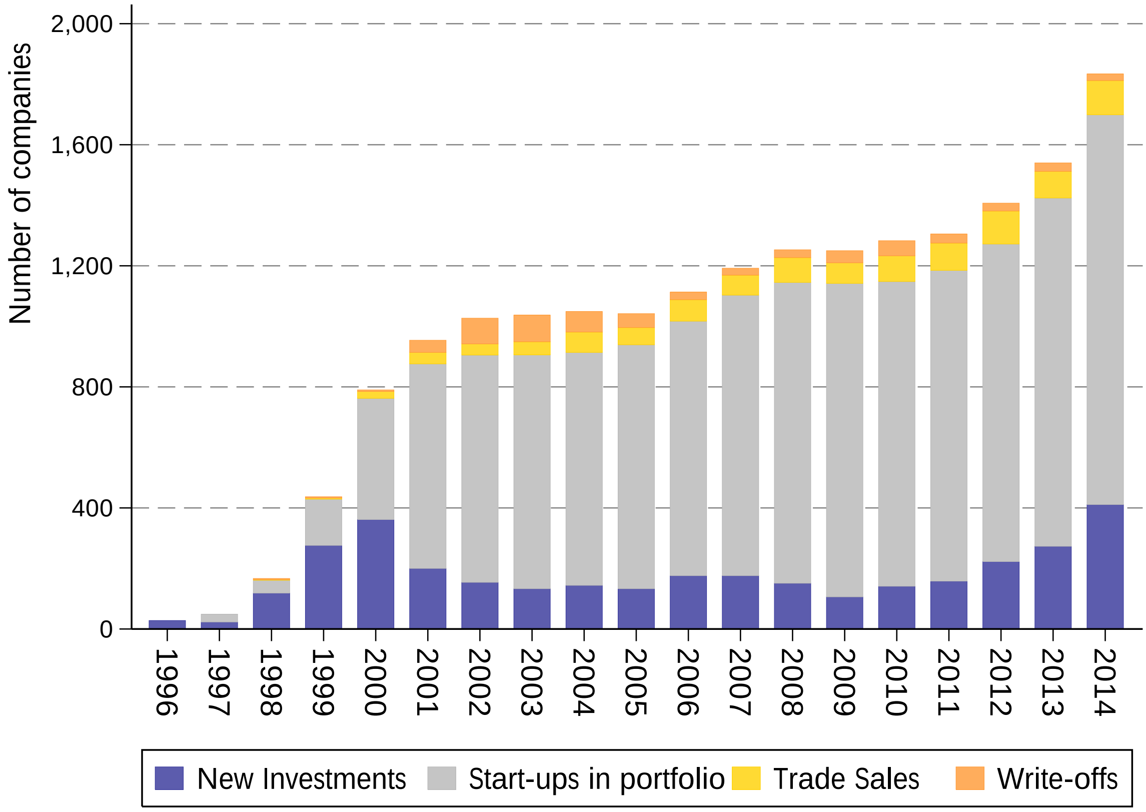
[12] For this reason, in our subsequent analyses we cautiously exclude some companies linked to more later stage deals. We give full account of our methodology in section 2.4.

[13] Companies receiving follow-on investments will also be included in this category.

[14] With the possible exception of 2009 and 2010, the harshest times of the recent economic downturn.

[15] Figures for 2015 were not included for lack of availability at the beginning of the analysis. Due to the recent increase of EIF activity following the capital increase in 2014, as well as the increase of Risk Capital Resources (mandate from EIB to EIF) in the context of the Investment Plan for Europe, figures concerning the portfolio described above are expected to increase significantly.

Figure 1: EIF VC portfolio composition by investment status[16]




## 2.2 EIF's role in the VC market

Data on investments provided so far constitutes a tangible evidence of EIF's relevance in the broader European VC landscape. However, while such statement is widely acknowledged in notional terms, attempts to quantify EIF's role have only seldom surfaced the public sphere. Undoubtedly, there are several legitimate reasons for this to be the case: the significant challenge in retrieving comprehensive aggregate data on European venture capital activity, as well as the sometimes impossible task of disentangling seed and start-up investments from pre-seed and later-stage deals. Nevertheless, the benefits of such exercise are manifest and, we deem, worth exploring.

We base our analysis on European venture capital activity data published annually by Invest Europe.[17] In particular, our interest focusses on investment volumes in the 2007-2014 period. Data refers to country level aggregates, according to the location of portfolio companies ("market statistics"), and exclusively within the "seed" and "start-up" investment stage bracket.[18] Together with investment volumes, we collect the number of portfolio companies receiving venture capital investments in the same period, also reported by Invest Europe. Figure 2 illustrates the outcome of a comparison between EIF-backed investment volumes and the overall volumes in the European VC market.

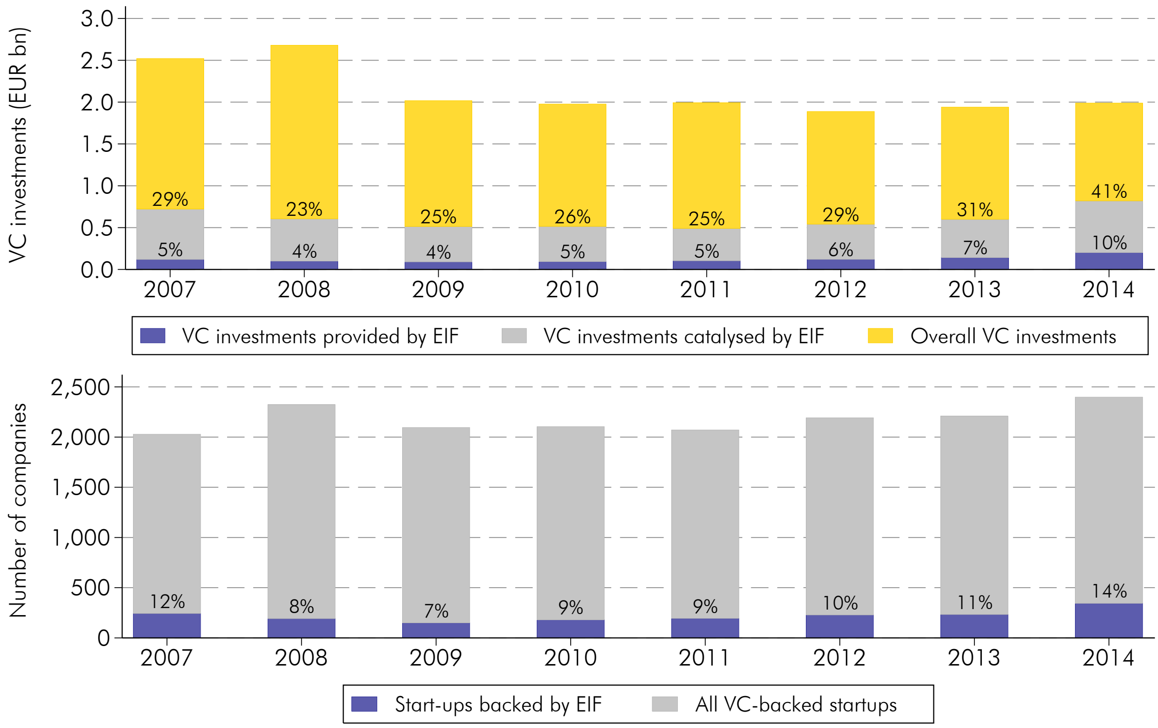
[16] Unless otherwise stated, all figures in this research are an elaboration of the authors, based on EIF data.

[17] Available at http://www.investeurope.eu/research/.

[18] Market statistics have complemented Invest Europe's annual "industry statistics" (*i.e.* amounts by country of VC firms' European offices) since 2007. Prior to that, only industry statistics were made available, limiting our analysis of the role of EIF to the 2007-2014 period.

For this exercise to be valid, we must ensure a full overlap between EIF and Invest Europe investments. In other words, EIF-backed investments that would not enter into Invest Europe's yearly aggregates are excluded, as they would incorrectly inflate the final results. Nevertheless, we are conscious that these investments, typically driven by pre-seed entities such as tech-transfer accelerators and/or business angel investors, do capture a significant amount of EIF-backed activity in the observed period. Moreover, EIF-backed investments targeted towards countries outside Invest Europe's radar are also excluded from the analysis.[19] All in all, these additional volumes are quantifiable at EUR 1.17bn in the 2007-2014 period. These amounts, not represented in the figures below, have been supported by EUR 225m of EIF-provided capital and relate to more than 800 worldwide investments into seed and start-up companies.

Figure 2: EIF's role in the European venture capital market

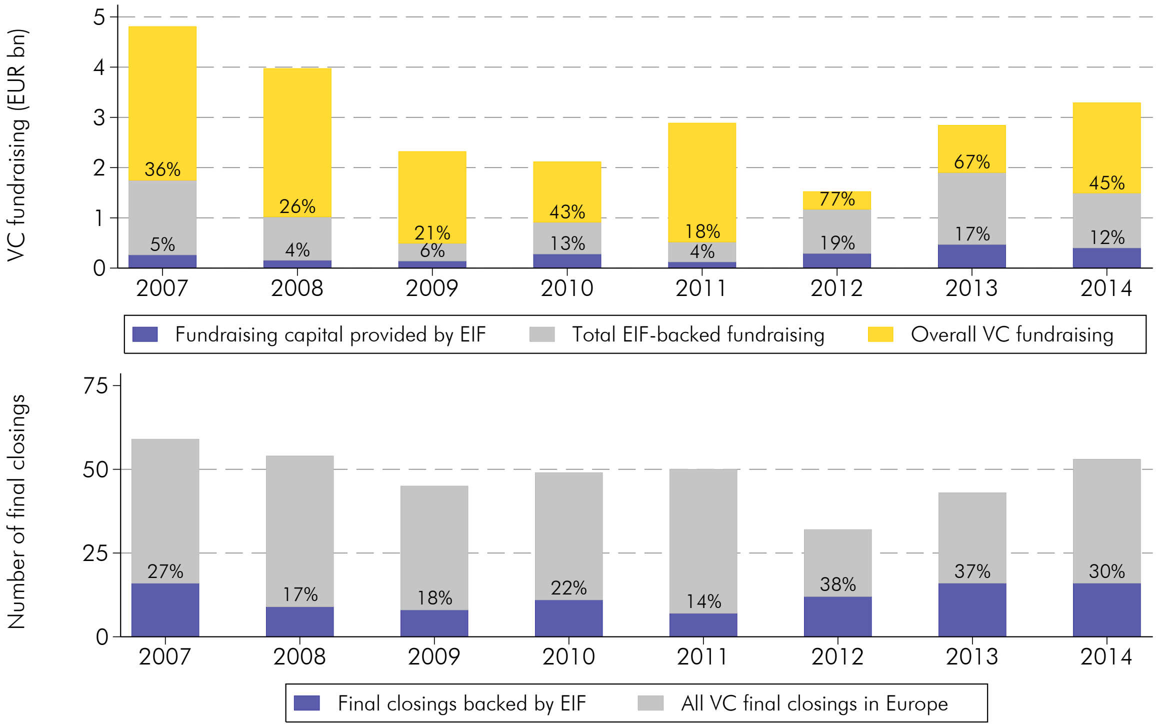



Note: superimposed percentages indicate the share of EIF-provided capital and EIF-backed investments respectively, over the total VC investments in the period

Figure 2 shows how EIF's engagement in the European VC market has significantly risen in recent years, in response to a drop and a subsequent stagnation of European VC investment levels. However, in order to fully appreciate the dynamics of EIF's counter-cyclical investment policy, it may be worth using a different metric for comparison: fundraising volumes. Also in this case, we base our analysis on data from Invest Europe, tracking the cumulative fundraising volumes at final closing date, in the venture segment. Similar to our prior analysis, we also collect the number of European final closings in the 2007-2014 period. Figure 3 depicts the role of EIF in European venture fundraising.

[19] Countries/regions covered by Invest Europe: Austria, Baltics, Belgium, Bulgaria, Czech Republic, Denmark, Europe, Ex-Yugoslavia & Slovakia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Ukraine, United Kingdom.

Figure 3: EIF support of European venture fundraising (cumulative fundraising at closing date)




**Note:** superimposed percentages indicate the share of EIF-provided fundraising capital and EIF-backed fundraising respectively, over the total VC fundraising in the period

Again, in order to ensure full overlap of the two data sources, we had to exclude a number of EIF-backed fundraising, totalling EUR 931m cumulated fundraising volumes in the analysed period. By combining Figure 3 and Figure 2, we can identify a sustained rise of EIF activity in support of the European venture fundraising starting from 2010. With a time lag of 1.5 to 2 years, the increased support to the venture capital market reached start-ups, with a significant rise of EIF-backed VC investments in the 2013-2014 biennium.

## 2.3 A call for impact

The rising significance of EIF's activity in the broader European venture capital landscape comes with its additional share of responsibilities. On the one hand, EIF is expected to demonstrate that different programmes supporting the European VC market are soundly managed, *i.e.* that the underlying investment strategy is efficient and return-oriented. On the other hand, as these programmes represent public policy interventions, it is essential for EIF to pursue the overarching economic goals set forth by the policy maker. For these reasons, EIF is expected to track not only the financial performance of the programmes it manages, but also the way these affect the broader economic sphere. Following this line of reasoning, we find the topical question: *are EIF VC activities effectively meeting the policy maker's goals?*

The question of impact assessment is relevant, for it helps distinguishing between effective policies and ineffective ones. And, we believe, its returns reach beyond the institutions engaging in its measurement, benefiting regulators and market players within the broader economic context. However, the challenges to answer such question are many, particularly in a traditionally hermetic sector such as the venture capital market. Against this background, it is perhaps not surprising to see a lack of European-wide studies attempting to assess the impact of policies in support of the venture capital market. This message is set forth in a recent OECD paper, which states that *"there is little evidence of the impact of these instruments [...]. [E]mpirical analysis of the outcomes of these programmes has also been scarce, in part due to challenges with seed and early stage financing data."* (Wilson, 2015b).

These questions define the main purpose of this paper. In fact, as there are several topics to explore in our investigation of the impact of EIF VC activities, we deem reasonable to disseminate these over the course of multiple publications. A dedicated series of papers that aims at providing a quantitative assessment of the impact of EIF-backed VC investments on the supported startups.

## 2.4 Data collection

It stands to reason that sound analyses would require a robust and transparent methodology. The analyses provided in this and further papers leverage on a meticulous data gathering process. We combined data reporting the details of EIF-backed VC investments with financial and demographic data of the targeted start-ups. The first part of our dataset is sourced from reports submitted by EIF-backed fund managers. By matching the denomination of invested companies and their head-quarter countries, we collected start-ups' financials and demographics from Bureau Van Dijk's *Orbis* database.[20]

At the end of this process, more than 91% start-ups' identies have been linked to their respective entries in the Orbis database. Such coverage does not automatically entail full availability of financial indicators for paired companies. Although this aspect is not directly relevant for the analyses provided in this paper, dealing with data availability issues will prove fundamental in future endeavors.

As expressed in section 2.1, EIF-backed investments into VC start-ups will typically constitute the first investment such company receives. However, we observe several cases in which this assumption cannot hold. Therefore, in order to restrict our analysis to "truly" first invested start-ups (so as to not bias our findings with data on companies that would not be classified as start-ups), we further screen our population of EIF-backed start-ups by adopting a set of assumptions that, in our view, are reasonably faithful to the abstract characterisation of start-up companies. We describe and motivate our assumptions in appendix A.

Overall, the screening of EIF-backed VC companies causes the population of analysed companies to drop from 3,389 to 2,934. The analyses carried in the remainder of this paper (as well as in future works) will exclusively focus on this subset of first-invested start-ups. In the future, companies assigned to the later stage category will be consolidated with all EIF-backed later stage investments and analysed separately.

[20] Bureau Van Dijk's (BvD) Orbis is a database containing information on over 198 million enterprises active worldwide (as of May 2018). Orbis contains up to 51 different firm-level financial indicators, either sourced from the firm's balance sheet or P&L account, and a series of 26 computed ratios. Recent additions to the database also include the number of patents and trademarks.

## 3 EIF-backed VC investments: a geographical perspective

In section 2.4, we have introduced the 2,934 seed and start-up companies EIF has supported during its first 18 years of VC activity. These are the beneficiaries of about 3,300 investments carried by 214 VC firms through more than 320 VC funds. One insightful approach to explore the patterns of EIF-backed VC investments is offered by the analysis of their geographic distribution, which will constitute the main focus of this chapter.

The geographic distribution of EIF-backed VC investments can be thought of as an intricate network of VC firms and start-ups, spanning throughout Europe and evolving over time. To illustrate this network, we geolocated 91% of EIF-backed seed and start-up companies, which account for more than 95% catalysed investments in these stages. Together with start-ups we also located VC firms' headquarters, in order to portray VC investments as links of our figurative network. The result of this exercise is illustrated in Figure 4, where start-ups are drawn as blue circles and VC firms as yellow squares. Investment flows towards start-ups are represented by colored links.[21]

To facilitate readability, when start-ups or VC firms are located in the same city we have distributed them around the city's focal point, creating a "cloud" of start-ups whose size is proportional to the number of companies invested in the area. While the information contained in Figure 4 is too complex and granular to be thoroughly analysed, it does provide an intuition on several descriptive features of EIF-backed start-ups. Some of these features, we argue, might also be relevant for the broader European VC market.

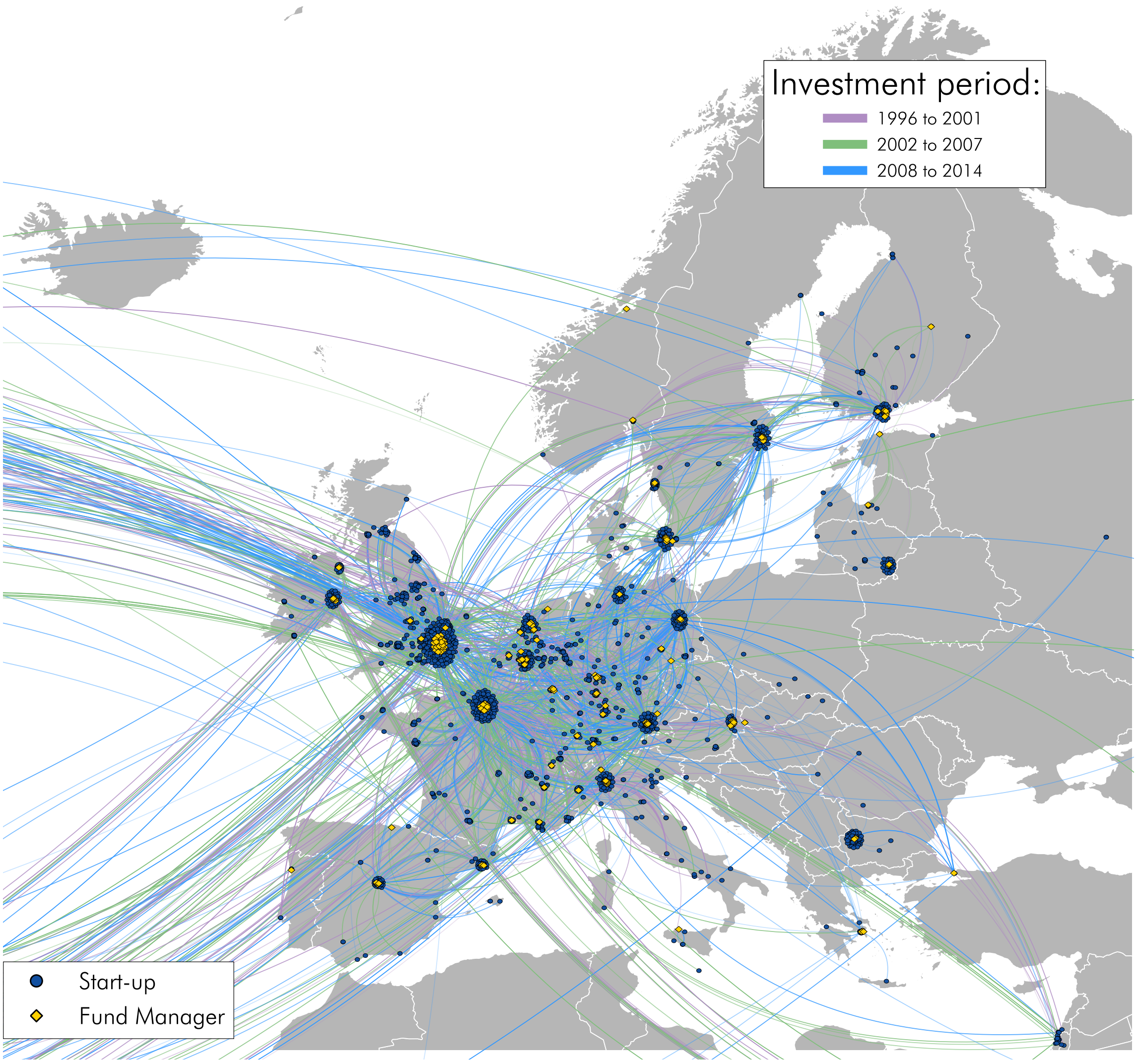
There are three noteworthy characteristics arising from Figure 4. First, EIF-backed investments spread unevenly across the European geography. This feature is visible both cross-country as well as within most European nations. EIF-backed VC investments have typically targeted the major European VC hubs, (*e.g.* London, Paris, Berlin, *etc.*), as well as regions affected by specific support programmes, through particular focus on seed and pre-seed investments (*e.g.* Leuven, Sofia, Goteborg, Espoo). We will delve in more detail into the analysis of European (and/or EIF-backed) VC hubs in section 3.1.

A second feature of the network in Figure 4 relates to the existence of numerous investment channels, *i.e.* investment routes consistently pursued over time, either by the same or several VC firms. Some of these channels seem to have emerged in relatively recent years (*e.g.* many of the investment routes leading to or originating from Berlin), while others constitute paths that have existed for a longer time period (*e.g.* the path connecting Paris to Milan). Interestingly, a number of channels actually depict mutual exchanges between areas. These define cross-investments paths, sometimes even cross-border, that are particularly worth of additional investigation. We explore these in section 3.1.2.

It is also important to remark the long-standing channel connecting key European hubs with the American venture capital sphere. Out of the total number of start-ups analysed, 6.5% have their headquarters based in the United States, and have attracted 9.5% of the overall EIF-backed investments. However, it is crucial to mention that a significant portion of these investments relate to ventures originally started on European soil, which later moved their headquarters to the United States.

[21] To the benefit of clarity, investments are depicted as undirected lines. However, the reader should consider that a link will always originate from a VC firm and terminate on a start-up.

Figure 4: A network of EIF-backed VC investments, from 1996 to 2014




A third and final finding is that the breadth of EIF-backed VC investments expanded over time. This is particularly noticeable for investments made in the 2008-2014 period (drawn in light blue in Figure 4), often treading paths that had not been traced before. The spatial dynamics of EIF-backed VC investments can be considered partly reflective of the development of the underlying European VC market, and partly stemming from specific European policy objectives and initiatives. These topics constitute the key focus of section 3.2.

## 3.1 European venture capital hubs

The geographical concentration of the VC industry among few catch-all areas is not necessarily a novel finding in the venture capital literature. This aspect is discussed in Lerner *et al.* (2011), and Mason (2012) provides an exhaustive overview of the literature on the spatial distribution of European VC firms. However, rarely have studies addressed the geographic distribution of VC investments (*i.e.* the underlying start-ups), especially for the case of Europe. A noteworthy exception is Sorenson and Stuart (2001), who analysed US-based VC investments in the 1986-1998 period. More recently, Florida and King (2016) concluded that, in 2012, the 20 best performing European metropolitan areas accounted for more than 60% of venture capital investments in Europe.[22]

### 3.1.1 A quantitative definition of venture capital hub

To contribute to this relevant strand of research, we must first address the non-trivial task of identifying (European) VC hubs. This entails the selection of a suitable metric to single out key areas of EIF-backed VC activity. As is customary in the field we begin by ranking cities based on activity volumes, specifically those related to EIF-backed VC investments, attracted by their startups over the last 20 years. We conduct the analysis using three different time-windows that, compared to the ranking of the overall period, help to shed further light on the underlying trends. Moreover, to counter the issue of cities with a single sizable deal prevailing over areas benefiting from a constant streams of smaller investments, we impose a minimum number of investments that must occur for cities to classify as VC hubs. These thresholds are set to 7 for each time-window, and 20 for the overall period.[23] The results of this exercise are portrayed in Table 1, which offers several interesting insights.

A first remark is that the top rows of Table 1 are in line with existing rankings of European venture capital activity.[24] The recent dynamics of the European VC market are also well represented by *e.g.* the impressive rise in the ranking of Berlin in the 2008-2014 period, as well as the minor and major falls of Paris and Milan, respectively. One of the most interesting features of Table 1 concerns the period 2002 to 2007. While cities in the 1996-2001 ranking typically populate the 2008-2014 classification as well, the post dot-com period witnessed the fall of many until then thriving VC hubs, temporarily replaced by secondary hubs (*i.e.* centers that used to occupy lower rankings) on the rise.

The overall period rank (last column in Table 1) is certainly a faithful portrayal of the geographic concentration of EIF-backed VC investments. Can we argue that it also traces an accurate profile of the general market trends? To some extent, yes: 16 out of the top identified cities can be also found in the European Digital City Index 2015 (EDCi, NESTA 2015), which provides one of the most comprehensive (though hardly complete) list of European VC hubs to date. As per the four cities not in the list, with the sole exception of Hamburg — which seems to be more of a shortcoming of EDCi than an exaggeration of our ranking[25] — the rest does identify areas in which EIF may be more active than the overall market. In fact, the entire tail of the overall period ranking (*i.e.* positions 16 to 20) is indicative of areas in which EIF-backed investments may be more intense than the rest of the VC market. To accurately discern these two groups, it proves useful to look at the way different European hubs "communicate", by cross-investing into one another. After all, the use of the word "hub" for a venture capital city clearly hints to its ability to attract, but also radiate, venture capital

22 The ranking, based on data from Thomson Reuters, includes a number of cities that are not part of the European Union such as Moscow, Saint Petersburg and Istanbul.

23 These admittedly arbitrary thresholds are based on the concept that, on average, at least one investment targeted the candidate hub each year in the measured period.

24 See for instance Ernst & Young (2015), CBInsights (2014) and Florida and King (2016) for lists of top European VC hubs.

25 As proof of this, the analysis in Ernst & Young (2015) also ranks Hamburg among the top European cities for venture capital activity.

Table 1: Ranking of EIF-backed VC hubs by time window[1]

| City (country) | Rank 1996-2001 | Rank 2002-2007 | Rank 2008-2014 | Overall period rank |
|---|---|---|---|---|
| London (UK) | 2 | 1 | 1 | 1 |
| Paris (FR) | 1 | 3 | 3 | 2 |
| Cambridge (UK) | 4 | 2 | 6 | 3 |
| Berlin (DE) | 8 | 13 | 2 | 4 |
| Munich (DE) | 6 | 7 | 4 | 5 |
| Dublin (IE) | 5 | 4 | 10 | 6 |
| Milan (IT) | 3 | | 8 | 7 |
| Stockholm (SE) | | 9 | 5 | 8 |
| Amsterdam (NL) | 9 | 6 | 7 | 9 |
| Copenhagen (DK) | | 8 | 9 | 10 |
| Vienna (AT) | | 10 | | 11 |
| Hamburg (DE) | 13 | 15 | 11 | 12 |
| Madrid (ES) | 14 | | 14 | 13 |
| Barcelona (ES) | | | 12 | 14 |
| Helsinki (FI) | 10 | | 13 | 15 |
| Espoo (FI) | 12 | | | 16 |
| Leuven (BE) | | | | 17 |
| Goteborg (SE) | | | | 18 |
| Sofia (BG) | | | | 19 |
| Vilnius (LT) | | | | 20 |
| Belfast (UK) | | 12 | | |
| Bristol (UK) | | 5 | | |
| Cologne (DE) | | | 15 | |
| Leipzig (DE) | 15 | | | |
| Lyon (FR) | | 14 | | |
| Manchester (UK) | 11 | | | |
| Reading (UK) | 7 | | | |
| Valbonne (FR) | | 11 | | |

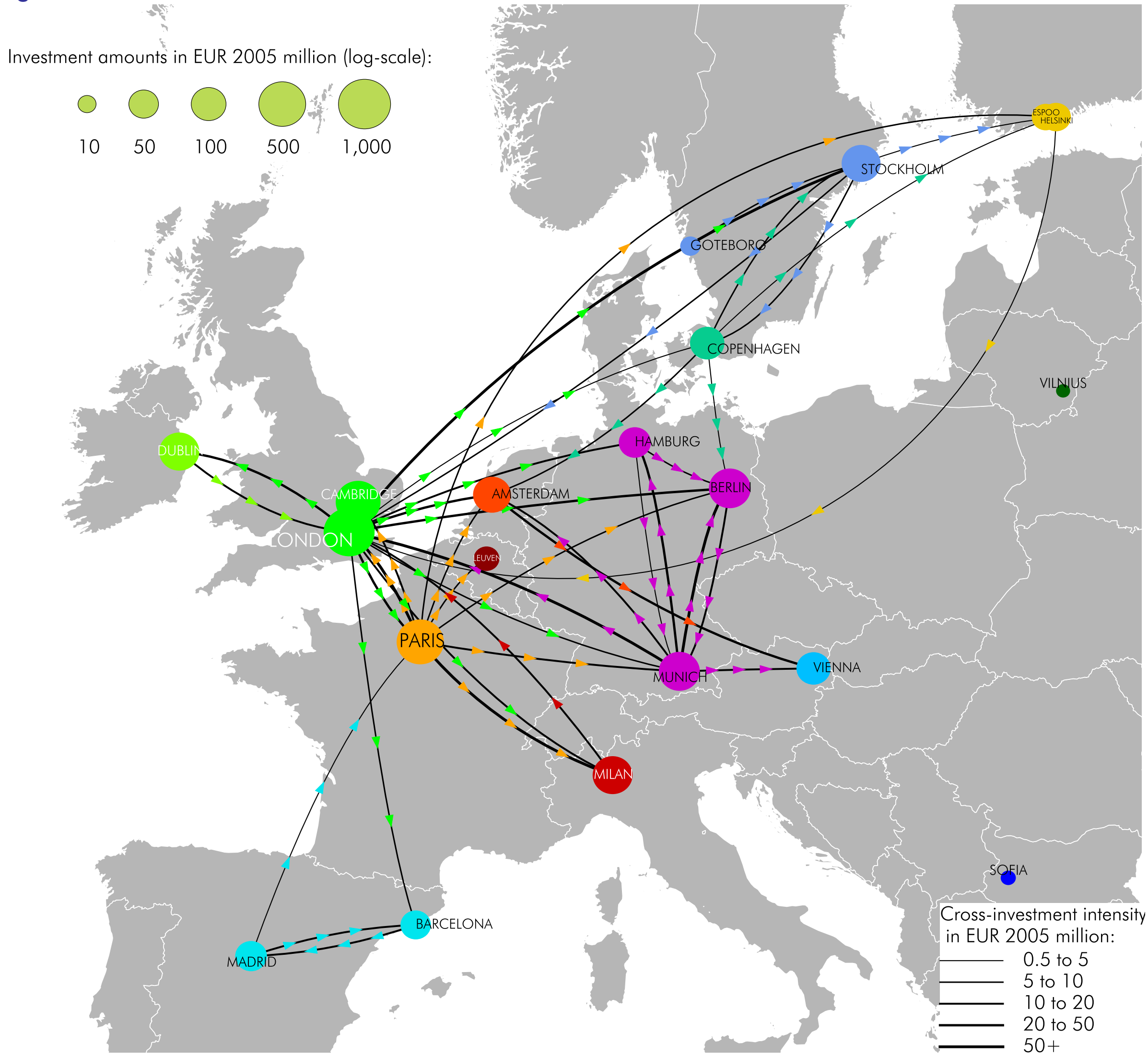
[1] Note: only ranking 15 or higher for time-windows, and 20 or higher for the overall period reported. Missing rankings indicate that the city did not classify among the top 15 for the specific time-window, or in the top 20 for the overall period.

investments across multiple ends. Against this background, we hypothesize that the more established a European VC hub is, the more interconnected it will be with other relevant European VC hubs. To prove our hypothesis, we begin from Figure 4 and isolate all the investment activity arriving to or originating from our top 20 identified hubs. By aggregating investments at city level, we obtain a new network, in which nodes represent cities. This new network is illustrated in Figure 5.

In Figure 5, each node size is proportional to the cumulative investments received by the hub in the 1996-2014 period. Investment channels across cities are represented by links, endowed with directional arrows to discern start from end. The size of a link reflects the intensity of the investment channel between two given hubs. Moreover, we discarded ”spurious” channels, defined as connections created by one single investment occurring throughout the 1996-2014 period.

Figure 5 offers several insights, and it provides substantial evidence against our prior hypothesis: among the five hubs discussed above (Espoo, Goteborg, Leuven, Sofia, Vilnius), only Espoo and Leuven have an established inbound connection with at least another hub in the ranking. As per the remaining cities, investments typically arrive from neighbouring secondary hubs or the city itself. While this finding might be a reflection of a bias towards seed and pre-seed investments characterising EIF-backed activity in these centers, we conclude that it might be still too early to consider these akin to

Figure 5: Cross-investments of EIF-backed VC hubs, cumulated values 1996-2014




Note: "spurious" links, (*i.e.* single investments over the analysed period) excluded from the representation.

more established VC hubs, for the reason that they do not yet show a sufficient level of integration with the core of the European VC market. While the ascent of a venture capital hub cannot be reduced to simply the lack or availability of capital, this exercise hints at EIF contributing to prospective hubs, by means of the investments channeled through mandates and programmes. To gain a more in-depth view of the areas of EIF's main activity over the past 20 years, the reader is referred to section 3.2.

### 3.1.2 Why are hubs important? Cross-fertilisation of EU VC hubs

In this section, we discuss about other noteworthy features of Figure 5,[26] which portrays a rather dynamic and interconnected system of European VC hubs. But how do hubs compare against the

[26] It is worth reinstating here that findings only relate to the portion of European VC ecosystem that is "visible" to EIF, and that additional, perhaps different trends may be observed when analysing the European VC market in its entirety. Further research should carry the weight of assessing whether these insights are representative of the entire European VC ecosystem.

overall European VC activity? By looking at the history of EIF-backed activity, we observe that the 20 cities illustrated in Figure 5 collectively attracted 39% of all EIF-backed investments in the period. Despite the high degree of concentration, we note that these major European hubs did not attract the majority of the overall VC activity.

However, hubs prove to be remarkable catalysers for investment creation: in the analysed time window, 83% of all invested amounts originated from the 20 hubs. Against this backdrop, it may prove informative to look at the geographical dispersion of hub-sourced investments. In particular with respect to cross-border activity, yet another feature evoked by Figure 5. Cumulated data shows that almost 42% of all EIF-backed VC investments overcame national borders. Note that this share may be peculiar to EIF-backed activity, typically carried by investors with a wide geographical focus: recent data from Invest Europe hints that the figure for the broader VC market may rather be in the neighbourhood of 31%. Notwithstanding potential differences in magnitude, we observe that venture capital hubs sourced 73% of all cross-border investments. The cities of London, Paris and Munich alone make up for 51% of all EIF-backed cross-border activity, as hinted by the numerous links stemming from these three hubs in Figure 5.

Data at hand, the picture drawn so far of the European VC ecosystem hints to an important, perhaps counter-intuitive, conclusion: that venture capital hubs are not necessarily the sole gravitational fields in an otherwise void ecosystem. Rather, they act as the beating heart of a complex network of national and international investments, often crossing each others' path in an apparently unordered fashion. Such claim is backed by data on investment amounts originated by hubs: the share remaining in the hub accounts for 23%, while 40% reaches out to other locations within the country. The remaining 37% will travel beyond the national frontier, typically targeting non-hubs.[27]

In light of the expansive behaviour of European VC hubs, it becomes easier to appreciate the intricate network depicted in Figure 5, not free from a number of visible patterns. For instance, London acts both as the gatekeeper of UK- and Irish-based hubs (*e.g.* Oxford, Manchester, Bristol), and the farthest-reaching hub in Europe. Paris instead monopolises the French ecosystem (let alone for some areas covered also by German funds), while also showing strong ties with South Europe (Milan in particular). Munich is the focal point around which the DACH VC scene revolves, while Copenhagen is a pivotal hub for the Nordic region. As for Italy and Spain, the significant role of their hubs in the national scene is only complemented by limited continental integration, as testified by one single strong link to either London or Paris.

In conclusion, venture capital hubs are a fundamental component of the European VC ecosystem. They channel a predominant share of the overall European and national activity, reverberating investments across the national territory and beyond. And they represent virtuous examples for prospective investors, as highlighted by Lerner *et al.* (2011), where the authors find that funds located in hubs perform better.[28] Thus, public policies in support of European venture capital should always be weighted against their potential impact on key hubs, whether contemporaneous or prospective.

[27] 26% of VC hubs' total activity reaches foreign non-hubs, while 11% targets other hubs abroad.

[28] However, the study's results are based only on US- and UK-based funds.

In this respect, it seems reasonable to assume that policies acting at the broader European level may prove more effective than national ones in fostering the integration and/or synchronisation of local ecosystems with the broader European VC landscape.

### 3.1.3 VC hubs and agglomeration patterns

We conclude our analysis of the role of hubs in the European venture capital landscape by analysing the location preferences of European start-ups. To do so, we focus on European-based startups: as extra-European investments are relatively rare in our data, such choice is rendered necessary to keep a meaningful definition of "hub". For each startup, we compute the *geodetic distance*[29] between its headquarters and the closest national VC hub.[30] The purpose of this analysis is twofold: on the one hand, we wish to provide some evidence in relation to EIF-backed startups' location preferences; on the other hand, we aim to shed further light on the startup profiles that mostly gravitate around the main European VC hubs.

Results are portrayed in appendix B. There seems to be a recent trend towards increased centralisation: compared to the 2002-2007 period, startups invested in the 2008-2014 time window are on average 65% closer to the main national hub. The finding becomes particularly relevant when one considers that, unlike most cases, it does not simply reflect a phenomenon already evidenced by 1996-2001 startups. An alternative explanation that challenges this view may claim that in the 2008-2014 period EIF has backed more funds based in VC hubs. This, coupled with the results in section 3.2, where it is shown that hub-based investors tend to perform short-range investments more often than others, could explain the observed trend. While the increase in hub-based investors backed by EIF in 2008-2014 is true, when controlling for this in our model the trend towards agglomeration described above remains significant.

As per our second research focus, results show that European VC hubs' gravitational pull affects mostly ICT and Service[31] startups. While this finding may simply be the reflection of ICT being the main target of VC investments (thus impacting the very notion of VC hub introduced in section 3.1), it could also hint to the different advantages arising from the decision to locate a venture close to the hub. However, our results do not imply that startups in *e.g.* the life science, manufacturing green-tech field benefit less from agglomeration *per se*, but rather that the advantages of doing so close to hubs are more limited than the benefits reaped by ICT startups in such case. Overall, further research is needed to assess how these results fit with the broader literature of industry agglomeration, which benefits from a wealth of theories since the early work of Marshall (1890).

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29 That is, the length of the shortest curve between two points along the surface of a mathematical model of the Earth.

30 This made it necessary to lenghten the list of hubs of Table 1. We do so by adding, for each uncovered state, the biggest center by gathered investment amounts. The final list of hubs is composed thusly: Vienna (AT), Leuven (BE), Sofia (BG), Geneve (CH), Plzen (CZ), Hamburg (DE), Berlin (DE), Munich (DE), Copenhagen (DK), Tallinn (EE), Barcelona (ES), Madrid (ES), Helsinki (FI), Espoo (FI), Paris (FR), Lyon (FR), Cambridge (GB), London (GB), Athens (GR), Dublin (IE), Milan (IT), Vilnius (LT), Luxembourg (LU), Riga (LV), Valletta (MT), Amsterdam (NL), Oslo (NO), Krakow (PL), Porto (PT), Bucharest (RO), Stockholm (SE), Goteborg (SE), Bratislava (SK).

31 This category collects startups operating in consumer, financial and transport service sectors.

## 3.2 Spatial dispersion of EIF-backed investments

In the previous sections we have delved into the dynamics of European venture capital hubs. However, as demonstrated earlier, these only catalyse a limited part of EIF-backed investments. In our analysis, we find more than 700 different locations in which startups have their headquarters. This remarkable figure was certainly evoked by Figure 4, but there is still room to improve our understanding of the spatial distribution of EIF-backed investments.

In order to provide a more accurate representation of the geographic dispersion of EIF-backed investments, we must depart from network representations and focus on appropriate measures such as the density of investment per square kilometer. We start with cumulated values of deflated investment amounts as of end 2014, obtaining a "heatmap" of EIF-backed investments as depicted in Figure 6.[32]

Figure 6 supports the claim that EIF-backed investments have spread throughout most of the European continent, albeit clearly concentrating around hubs. Moreover, appendix C depicts the geographic concentration of cumulated EIF-backed investments over time, allowing to appreciate even further the geographic expansion of EIF-backed activity in the last 20 years. A feature that is due to emerging policy areas (*e.g.* the CESEE region after the 2004 and 2007 enlargements) as well as rising VC hubs. As usual, it proves quite interesting to break down the overall findings by source location. In Figure 7, we look at the areas that investors from different regions target the most.[33]. While we observe an overall "home" bias — and a tendency to privilege short- and medium-range investments — in all regions, we also note significant differences among regions of origination.

These findings bring us to the concluding analysis of this chapter, where we seek to identify the determinants of proximity bias for EIF-backed VC investment. To do so, we compute for each investment the geodetic distance between the VC firms' main headquarters and the invested startup's location, and regress it over several characteristics of both the VC firm and the company. Our main interest in this analysis lies in discovering whether features related to the experience of VC investors affect their investment behaviour. A topic that benefits from a relatively well-nourished literature (see for instance Sorenson and Stuart 2001).

The results of this analysis are portrayed in appendix E. Controlling for several factors related to investor's preferences, we find that higher fundraising levels increase the distances covered by EIF-backed investments. However, the economic relevance of the effect is questionable: by taking average levels of fundraising volumes and distances covered, increasing fundraising volumes by EUR 1 million links to 1.2 km of additional covered distance. Interestingly, the finding seems to particularly affect mid-range investments. While fundraising volumes may be considered a good proxy for investors' experience, we note that an alternative index of experience, *i.e.* whether investments are carried by first-time investors, has no tangible impact on their spatial dispersion. Thus, further

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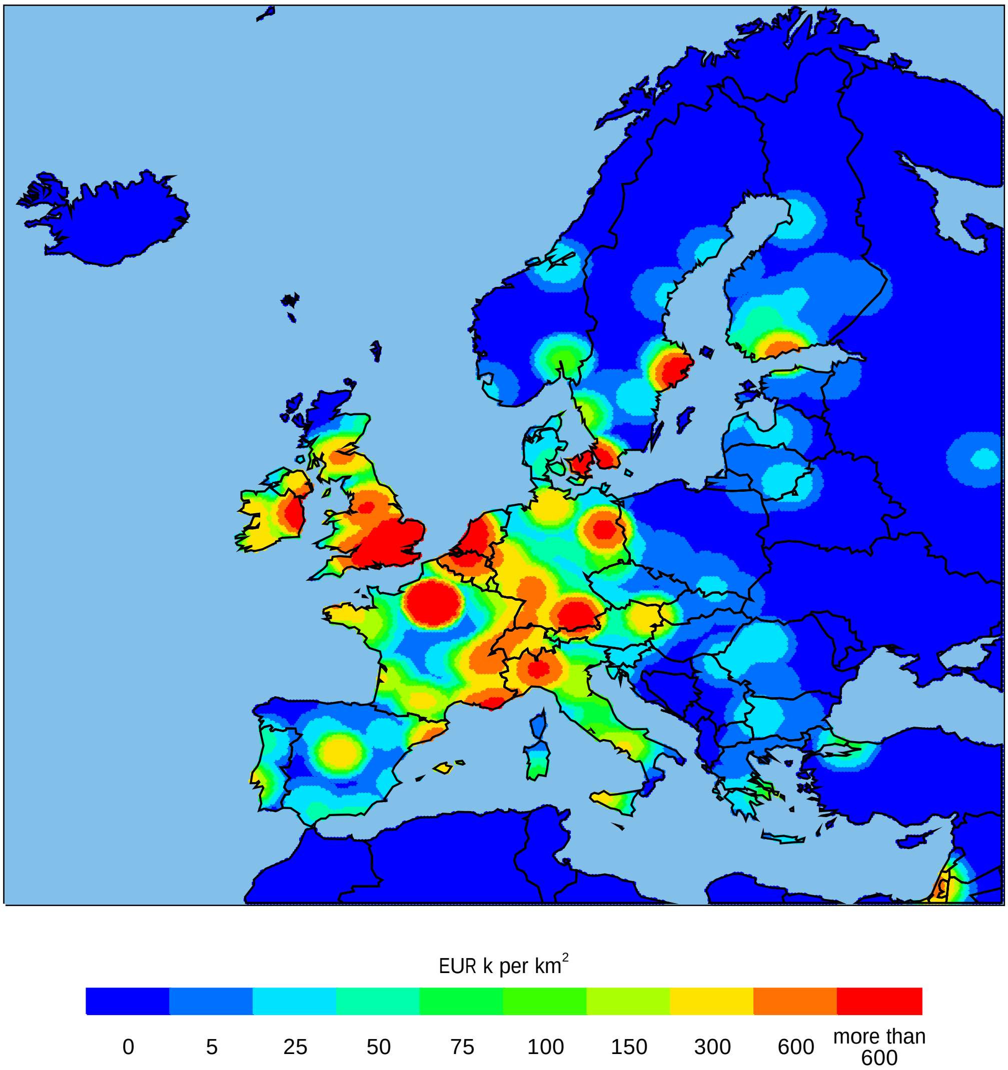
[32] All heatmaps presented in this section and in the appendices are estimated via a quartic kernel function and a fixed bandwith or approx. 17,500 km$^2$, *i.e.* the area of a circle with diameter 150km. All maps were created using the software in Pisati (2007).

[33] Investment trends over time by source region are available in in appendix D. The nomenclature of European regions is as follows: BI (British Isles): IE, UK; CESEE: BG, CZ, EE, LT, LV, PL, RO, SK, TR, CY; DACH: AT, CH, DE; FR&BENELUX: BE, FR, LU, NL; NORDICS: DK, FI, NO, SE; SOUTH: GR, ES, IT, PT.

Figure 6: Geographic dispersion of EIF-backed investments




Note: Cumulated initial and follow-on investments as of end 2014. All amounts expressed in EUR 2005 prices.

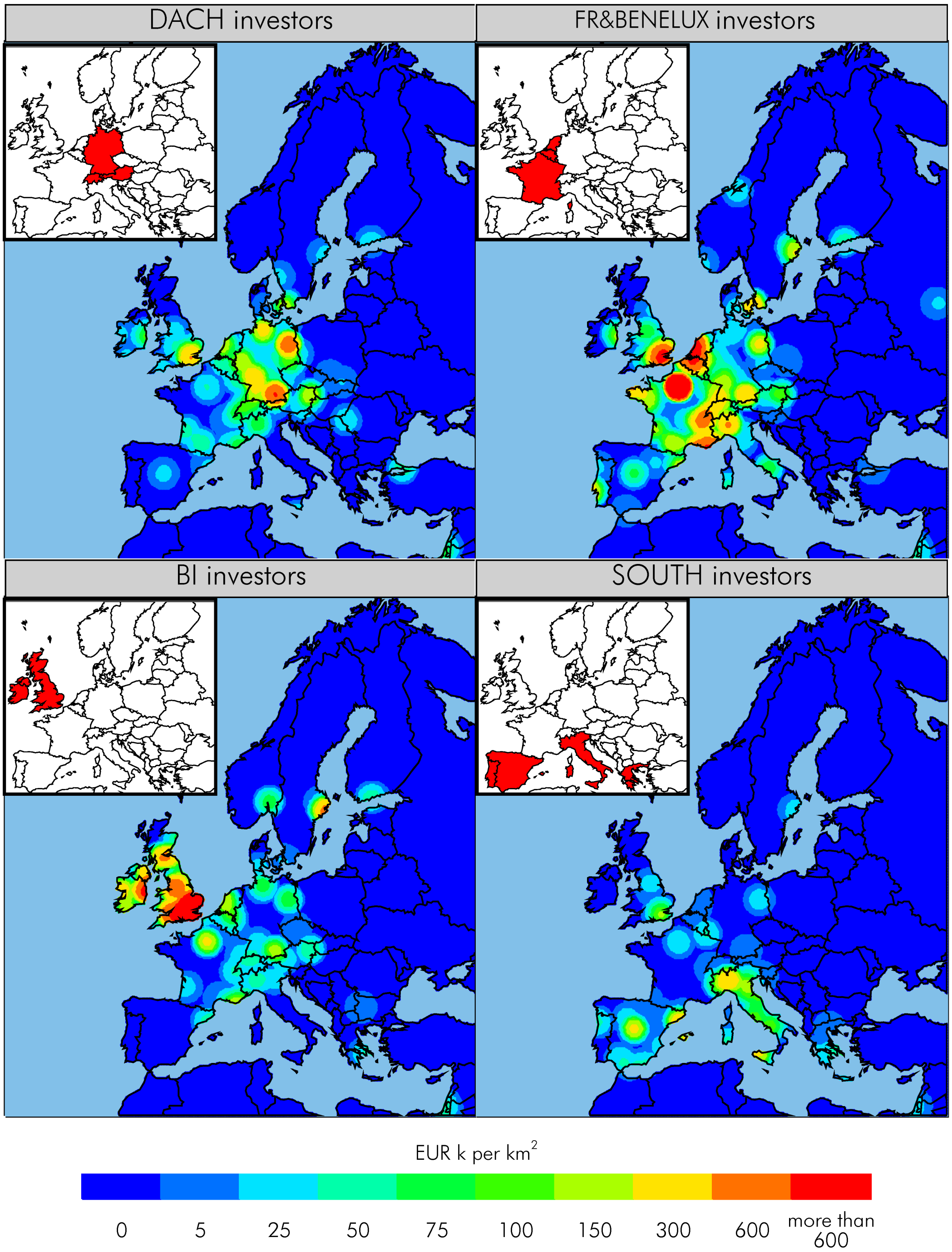
research is required to discern a possibly causal relationship between investors' experience and investment preferences. Moreover, our analysis does not account for the role of trust in investment decisions, shown to be particularly relevant for cross-border VC financing (Bottazzi *et al.*, in press).

## 4 EIF impact on the VC ecosystem

The numerous insights evidenced by section 3 thoroughly describe the spatial distribution of EIF-backed VC investments. However, not many of these can be naively ascribed to underlying trends of the general market, of which the EIF-backed portfolio only constitutes a subset. Against this backdrop, not much has been said on what happens to the venture capital ecosystem[34] in a given geographic area in the aftermath of EIF's increased activity. So far, anecdotal evidence, mainly driven

[34] A *VC ecosystem* here is defined as the full set of both privately and publicly funded market players who directly finance companies, and the VC investments associated to them.

Figure 7: Dispersion of EIF-backed investments by selected region of origination




Note: Cumulated initial and follow-on investments as of end 2014. Regions of origination marked in red in superimposed maps. All amounts expressed in EUR 2005 prices. For the composition of regions refer to footnote 33.

by the practitioners' knowledge of the market, has highlighted the importance of EIF investments in catalysing new private risk capital via both *signalling* and *critical mass* effects (see section 1).

However, the pure narrative approach falls short at encompassing a number of topical questions, notably: what is the causal effect of EIF VC activities in a given region on the region's VC market development over time? How does this impact vary according to geographic and economic factors? Finally, does the Fund really make a significant impact on the general European venture capital ecosystem?

In light of the above, little or no empirical evidence has been produced so far. Notwithstanding, as argued in section 2.3, the need to address these questions is important. Not only for academic or business purposes, but particularly for policy-makers and the broader public, in order to raise awareness and enable a deeper understanding of the extent to which market-intervention policies of this sort are able to effectively *crowd-in* new investments, supporting the VC ecosystem in a sustainable way.

In this section, we investigate these issues by using a unique dataset of VC investment amounts *at regional level*. We take advantage of EIF proprietary micro-data about VC investments carried out by EIF-supported VC funds into companies from 1996 to 2014. For each transaction, we retrieve the "EIF share" of the investment, according to the EIF equity stake in the specific fund. Next, we aggregate our data at NUTS-2 level[35] allowing for a comparison with regional data on VC activity levels from Invest Europe. Further information is retrieved from Eurostat, in order to build a single regional-level panel dataset encompassing 223 NUTS-2 regions from 2007 to 2014.[36] We test the presence of additionality effects of lagged EIF investments on the VC ecosystem, by estimating a dynamic panel data model for VC investment levels in European regions. In doing so, we control for year and region-specific effects. Moreover, the model takes into account variables useful to predict the size of the regional venture capital investment, such as employment density, educational level and the unemployment rate.

The relationship between the overall amount of VC investments and the size of the EIF intervention in the private equity market is clearly characterized by circularity. That is, to assess *which-causes-what* is far from trivial. The simultaneity arising from the dependent and the independent variable being *co-determined* poses major challenges for the estimation of a causal impact. We address the underlying endogeneity issues by employing several Generalized Method of Moments (GMM) dynamic panel data estimators.

Overall, during the 2007-2014 period, we observe EIF funding in a given year to carry, on average, a positive and statistically significant causal effect on regional investment amounts provided by other market players the year thereafter. Tests of instruments exogeneity and model specification corroborate the validity of the estimates, alongside several robustness checks. Interestingly, we find this *crowding-in* dynamics to be more pronounced in regions with a lower tertiary education achievement level. This feature hints at the *signalling* and/or *critical mass* effects of EIF being more pronounced in less economically developed areas (*e.g.* southern and eastern Europe), usually characterized by lower educational levels and, highly correlated, less established VC markets.

The remainder of the section is organised as follows. In section 4.1, the theoretical framework and the empirical strategy are outlined. Accordingly, we introduce the data in section 4.2, while section 4.3 describes the estimated econometric model and its main features. Finally, the results are portrayed

[35] The NUTS classification (*Nomenclature des unités territoriales statistiques*) is a hierarchical system for dividing up the economic territory of the EU for the purpose of the collection, development and harmonisation of European regional statistics. For more information, see http://ec.europa.eu/eurostat/web/nuts/overview.

[36] See appendix F for a list of the regions included in the analysis.

and discussed in section 4.4.[37] Section 4.5 concludes by discussing the robustness and potential limitations of our results.

## 4.1 Methodology

Designing an empirical strategy to assess the impact of EIF activities on the broader VC market's development poses several theoretical challenges. To these, there is the added challenge of identifying suitable metrics: which are the variables to be measured in such a framework? As illustrated in section 1, the EIF mainly acts in the private equity market as a *fund-of-funds*, that is, it does not engage in direct investments into companies. Therefore, the main policy tool used to catalyze actual VC financing is *the amount of investment into VC funds at the fundraising stage*. Accordingly, a typical case scenario would be: EIF contributes to the fundraising of a VC fund located in region $A$;[38] the fundraising team further deploys VC investments over a fund-specific time horizon (*e.g.* 8-10 years) into $n$ companies located in regions $A$, $B$ and $C$. In a multi-step framework of this sort, to measure the level of EIF activity in a specific region and a specific year is no straightforward task. In order to build an empirical model, we need to make assumptions that help us to simplify the underlying structure of the process. Moreover, these assumptions are useful to quantify the degree of EIF intervention in the market within a certain region-year cluster, without abstracting too much from the real mechanism at work:

Assumption 1. *The EIF acts in the market as a co-investor alongside VC firms.*

Although in reality EIF mostly operates as a fund-of-funds, Assumption 1 is harmless from an empirical analysis standpoint. Indeed, the focus of our research does not pertain to the investment strategy of VC firms (*e.g.* the choice to invest in a particular company, as opposed to other potential candidates). Instead, our focus is on the overall VC investment volumes, which are in turn depend on how much has been raised at the fundraising stage, the time window in which EIF investment decisions actually take place. Assumption 1 also conveniently allows to model the European VC ecosystem as a market in which three agents invest into startups:

1. Non-EIF-backed VC funds;
2. EIF Co-Investors;
3. EIF,

where the coupling of 2. and 3. above yields investments carried by EIF-backed VC funds. In addition, combining 1. and 2. gives the amount of VC investments not pertaining to EIF disbursed

[37] Since the main goal of this paper is to give an overview of the EIF operations in the VC market, this section cannot explore the full theoretical, modeling and data-related details that this subject would deserve. Thus, an extended analysis of the VC ecosystem effect will be carried in future endeavours.

[38] Note that at this step, although most of the supported funds have a more or less broad geographic focus in their investment strategy, the EIF does not choose a priori the *exact* geographic distribution of the future investments.

capital, which we call *private investment*.[39] In light of this, we are able to derive the portion of EIF-backed VC investment directly pertaining to the EIF, and to mark it as "EIF investment", according to a criterion defined as follows:

Assumption 2. *The share directly attributable to EIF in a co-invested amount is equal to the EIF's equity stake in the VC fund at the end of its fundraising.*

Suppose, for instance, that an EIF-backed VC fund invests EUR 100 in company A. Then, were the equity stake of the EIF in the VC fund to be 40%, Assumption 2 implies that the "EIF investment" into company A is EUR 40.[40] Although being a simplification, this assumption is effective, because it permits to measure the EIF activity in the VC market *at the investment stage* without loss of generality. This measure, which is a proxy for the EIF "policy tool" (*i.e.*, the degree of intervention in the venture capital market), represents the variable whose effect we seek to estimate in our econometric set-up.

In order to assess the EIF impact on the EU-wide VC ecosystem, we ground our empirical strategy on regional data at NUTS-2 level. The first straightforward advantage of using regional data is the enlargement of the sample size with respect to country data.[41] Furthermore, as opposed to VC data at country level, the deeper granularity of regional data better reflects the true spatial distribution of VC investments.[42] As discussed in Martin *et al.* (2002), Sunley *et al.* (2005), Munari and Toschi (2015) and in section 3.2, the peculiarities of the different regions affect the different VC dynamics and their specific geographical spread within the country. Thus, the higher degree of variation in the data due to intra-country inter-regional differences is beneficial, as it facilitates the correct identification of the parameters of interest.

As we are interested in studying the EIF effects on the ecosystem over time, cross-section data, however granular, are not sufficient. By exploiting the time dimension in our panel, we estimate a dynamic model in which the regional level of VC investments today is a function of its previous level[43] as well as of other lagged explanatory variables, among which the EIF one. Other than to alleviate the simultaneity bias, using lagged controls reduces the extent to which these variables are "bad controls" in the sense of Angrist and Pischke (2008). Overall, a dynamic panel data model allows

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39 The term "private" here does not reflect the legal nature of investors: investments carried by public investors will also enter this category. Instead, it reflects the perspective of EIF to identify all VC capital not provided by EIF itself.

40 EUR 60 is then not attributable to EIF but to other investors belonging to the VC ecosystem.

41 Recent Monte Carlo evidence shows that a small sample size in the panel, typical of country data studies, is not particularly harmful for the validity of the estimates when the series show persistency (Soto *et al.*, 2009). Nevertheless, unit-root behavior is not ascertained for the VC market investment series within the panel. Moreover, the need to prevent "too many instruments" bias in finite sample requires the number of individual units in the panel to be at least as big as the number of instruments used, as a minimal rule of thumb (Roodman, 2009). Accordingly, the larger sample size guaranteed by using EU regions data becomes essential.

42 The higher the level of data aggregation, the more likely is that underlying microeconomic dynamics may be obscured by aggregation biases (see Nickell 1986).

43 Even when the coefficient on the lagged dependent variable is not relevant to our aim, allowing for autoregressive dynamics in the underlying process is key for retrieving consistent estimates of other parameters (see Bond 2002).

both time and cross-variation in the regional data to be used to build consistent parameter estimates by means of GMM techniques.[44]

## 4.2 Data

We are interested in studying the early-stage propeller role of EIF. In particular, we focus on EIF's ability to trigger additional equity investments not only for the seed/start-up segment of VC, but also for further investment stages. In doing this, we hypothesize an additional channel through which EIF investments may impact the VC ecosystem: that increased EIF-backed investment supporting the creation and gestation of successful startups may further lead to additional later stage investments (*e.g.* expansion, growth capital). For this reason, we include later stage investments in the segment of the VC ecosystem not pertaining to EIF (*i.e.* our dependent variable), but exclude them from EIF investment amounts (our regressor).

For our empirical analysis, we gather data from several sources. With regards to EIF data, we leverage on the Fund's internal database of equity transactions (EIF towards EIF-backed funds) and equity deals (EIF-backed funds towards portfolio companies), reported by the VC funds on a quarterly basis. For each VC fund, we calculate the EIF equity stake. Accordingly, for every equity investment into startups made by the EIF-backed VC funds, we compute the EIF share by multiplying the actual investment amount by the EIF equity stake in the originating VC fund, as motivated in section 4.1.

The outcome is a micro dataset in which 2,934 seed and start-up companies, backed by EIF from 1996 to 2014, are linked to the amounts invested by EIF-backed VC funds (see section 2) and, in light of the above, the respective EIF share. As well documented in section 2 and section 3, these companies, and therefore the related investment amounts received, have been geolocated in the data collection phase, by means of Bureau Van Dijk's Orbis database. This enables to allocate startups and investments to their respective NUTS-2 region, associated to each company's headquarter.[45] Subsequently, company level micro-data is aggregated at region-year level, so as to obtain a balanced panel of EIF and EIF-backed investments for 185 NUTS-2 regions observed from 1996 to 2014.

EIF and EIF-backed regional investments are further linked to regional-level data on the total amount of early and later stage VC investments, provided by Invest Europe.[46] The Invest Europe panel

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[44] An alternative modeling strategy for our problem would involve the use of structural models, such as *e.g.* panel Structural Vector AutoRegressive (SVAR) models. Nevertheless, the need for imposing restrictions on the model behavior requires these restrictions to be grounded in a theory of the underlying economic mechanism at work, which is far from straightforward in our case. For a review on panel SVAR, see Canova and Ciccarelli (2013).

[45] If not directly available in Orbis, information on NUTS-2 regions was retrieved in a 2-steps process: *1)* retrieval of the geographic coordinates from address/city information available; *2)* computation of the NUTS-2 region by means geographic coordinates and reference NUTS-2 maps provided by Eurostat. For further details on the STATA programs used to perform this, see Brophy *et al.* (2015), and Ozimek *et al.* (2011).

[46] Regional VC data and statistics are not regularly released by Invest Europe. The Invest Europe regional dataset has been produced in collaboration with EIF in the context of a broader research project that entails, inter alia, the study of the European VC ecosystem.

entails information for 203 NUTS-2 regions over the years 2007 to 2014. Because this variable is essential to our measurement of the impact of EIF activity, we are obliged to restrict our analysis to the 2007-2014 period,[47] *i.e.* during and after the subprime financial crisis started in 2007.

To the best of our knowledge, Invest Europe data represent the most reliable quantitative representation of the VC ecosystem in Europe, as most of the collected information is sourced directly from VC firms. Nevertheless, this variable cannot be used in our model as it is. Being representative of the entire VC ecosystem, it contains EIF investments. Therefore, as we are interested in testing the presence of a crowding-in of *external* non-EIF capital, to avoid double-counting we subtract the EIF share of both early and later stage investments from Invest Europe aggregates. That is, the dependent variable in our model is calculated as the total VC investment amount per region minus the sum of early and later stage investments provided by EIF (derived as the share of total EIF-backed investments). By bundling together the two data sources, we obtain a panel dataset with 223 NUTS-2 regions where either EIF or other VC market players have invested in the 2007-2014 period.

Moreover, for each region and year in our panel, we retrieve region-specific economic, geographic and social data from Eurostat (see appendix G) that we use as controls in the econometric specification, as discussed in section 4.1. All monetary values in the dataset are converted at constant prices (basis year 2005 = 100) by using Producer Price Index (PPI) country-specific deflators from Eurostat and OECD.[48]

Table 2 provides summary statistics for the main variables used in the empirical analysis. Two points are worth discussing. The first one is the remarkable difference between average and median values of the VC investment distributions, both for EIF and the market. For what concerns EIF investments, the median is 0, implying that out of the total region-year observations more than 50% witnessed no EIF-backed VC investments.[49] This finding is a clear signal of the agglomeration pattern in venture capital investments. As venture capitalists will typically look for entrepreneurs endowed with high human capital levels, we deduce that investments will accumulate in regions characterized by a higher percentage of high-skilled workers, typically those with large metropolitan areas and high population density (Glaeser and Resseger, 2010; Martin *et al.*, 2002). As shown by the comparison of Figure 8 with Figure 6, VC investments seem to mirror the spatial distribution of regional employment density, that is, the investments are mostly concentrated in *few regions* with a high concentration of population.

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47 However, as per the use of valid instruments in the GMM estimators, we are not restrained in the use of EIF and Eurostat variables outside the described period. In fact, the use of data starting from 1996 is beneficial to our estimates, as described in section 4.3.

48 Although from a theoretical perspective the use of Gross Fixed Capital Formation (GFCF) deflators would be more suited for VC investments, country and time-wise data availability issues have prevented us to go for this option.

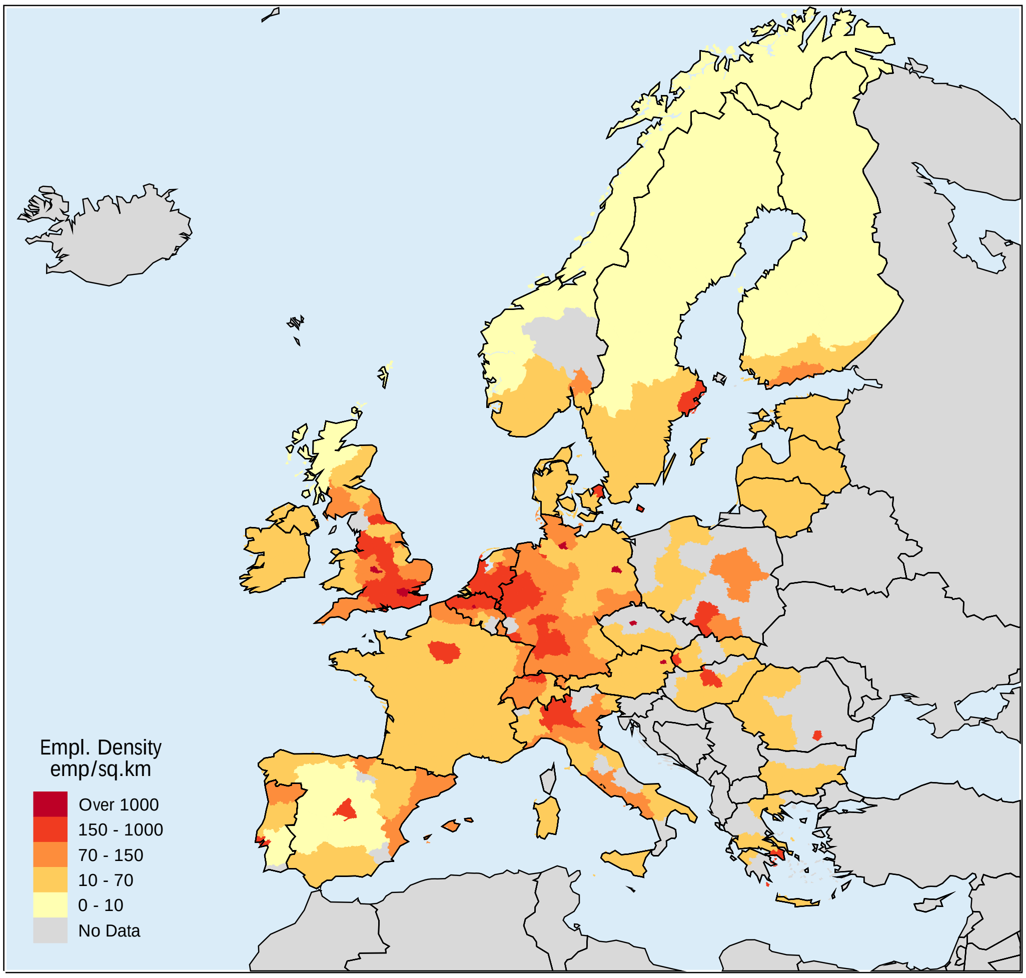
49 By looking at year-by-year figures, we confirm the intuition that, in general, more than 50% of EU regions have received no EIF-backed VC investment in the 2007-2014 period.

Table 2: Summary Statistics (Years: 2007-2014)

| Variable | Mean | Median | Skewness | Kurtosis | Min | Max | Obs |
|---|---|---|---|---|---|---|---|
| Non-EIF VC market inv. (EUR m) | 17.09 | 4.35 | 7.17 | 74.44 | 0 | 624.23 | 1784 |
| EIF VC inv. (EUR m) | .45 | 0 | 7.46 | 85.22 | 0 | 24.78 | 1784 |
| Tertiary education (% Pop.) | 28.28 | 28.2 | .25 | 2.99 | 10.8 | 62.4 | 1776 |
| Unemployment rate | 6.83 | 5.7 | 2.18 | 9.28 | 1.3 | 33.4 | 1773 |
| Empl. density (emp./sq.km) | 183.62 | 69.96 | 6.84 | 62.54 | 1.40 | 5360.78 | 1776 |

Note: The sample includes observations from 223 NUTS2 regions observed for 8 years. Source: Invest Europe (2016), Eurostat (2016), authors.

Figure 8: Employment density by NUTS-2 region, year 2014

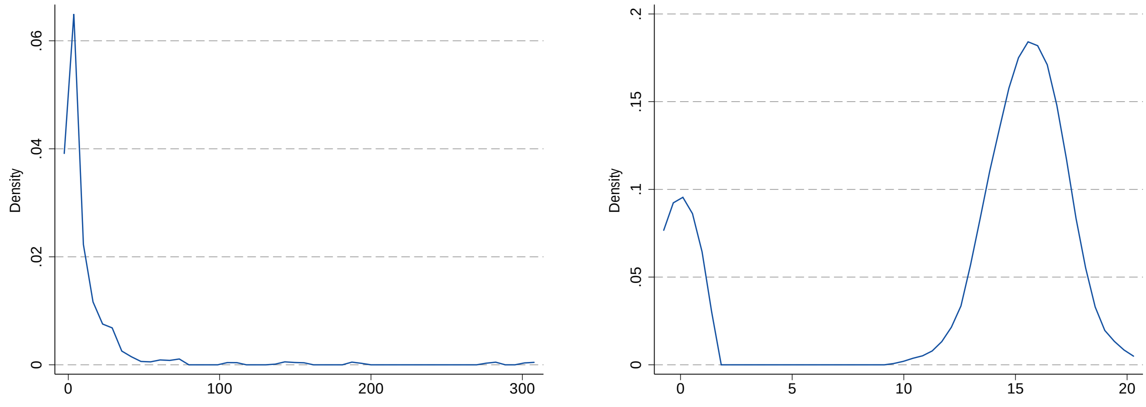



Source: Eurostat (2016), authors

The second point, a derivation of our first, pertains to the meaninglessness of averages when analysing VC dynamics. When the underlying data is inherently characterized by the presence of outliers, rather than the mean one should focus on higher moments of the distribution, such as skewness and kurtosis.[50] As Table 2 shows, for both EIF and other market players, VC investment distributions' main feature is right-skewedness, *i.e.* the majority of the EU regions having low or zero values of VC in-

[50] Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. Kurtosis is a measure of whether the data are fat-tailed or light-tailed relative to a normal distribution. That is, data sets with high kurtosis tend to have fat tails, or outliers. Data sets with low kurtosis tend to have light tails, or lack of outliers. A uniform distribution would be the extreme case.

Figure 9: Regional VC investment distribution: skewness and heavy tails




(a) Non-EIF VC Market Investment (EUR m)

(b) Non-EIF VC Market Investment (Logarithm)

Note: distribution density based on 2014 data for 223 NUTS-2 regions. Source: Invest Europe (2016), authors.

vestments within their borders, and fat-tailedness,[51] *i.e.* few NUTS-2 regions hosting VC *hubs* (see section 3.1) that capture the largest part of the total EU-wide VC investment amount. Indeed, venture capital is a domain of outliers. Figure 10 shows the trend of VC investments in the key *regional hubs* over time, for both EIF-backed and non-EIF-backed investments.

## 4.3 The Model

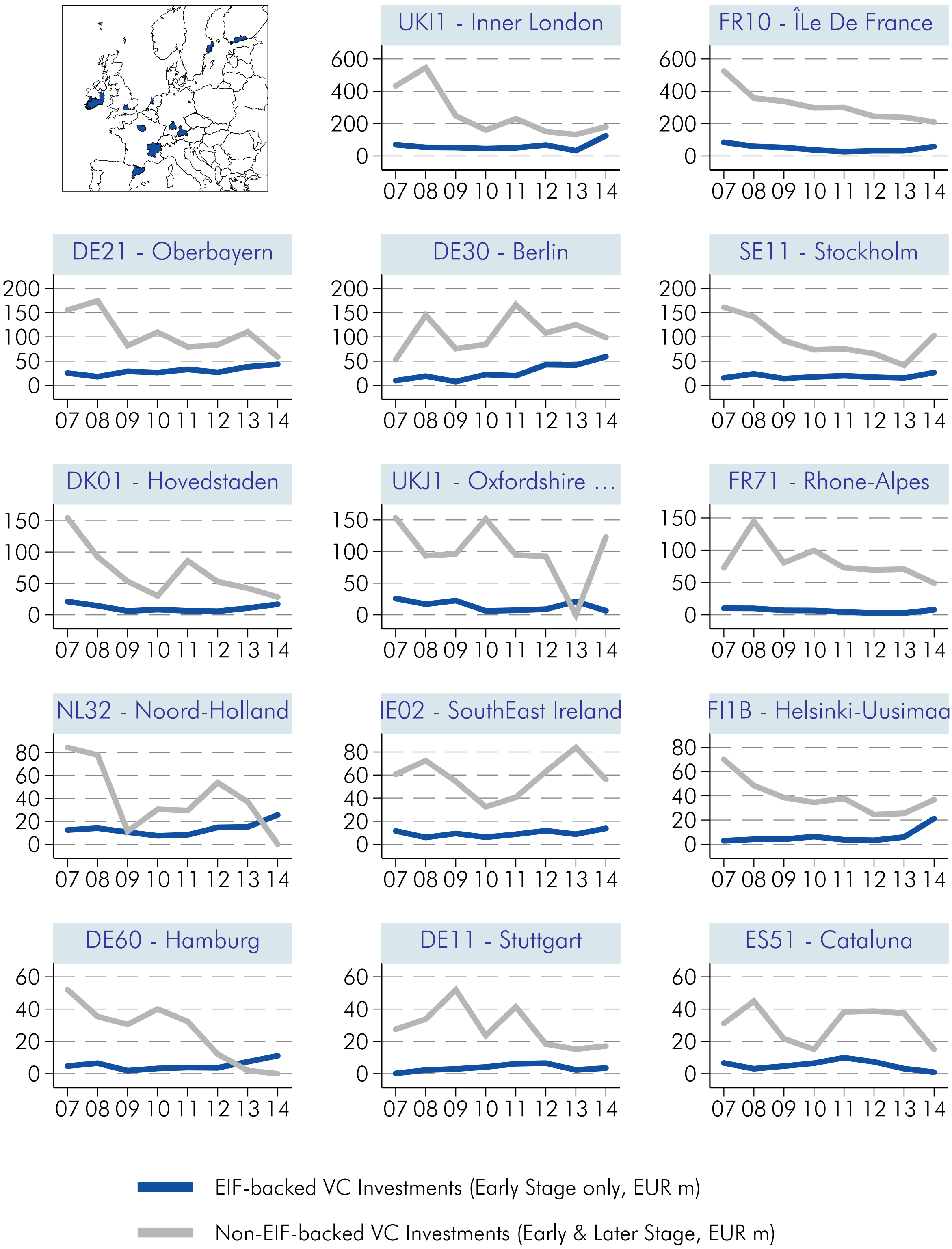
We seek to estimate the causal effect of EIF investments in one year on the amount of VC investments provided by other market players in subsequent years. To this end, we estimate a dynamic panel model, addressing endogeneity issues by means of GMM techniques. Our dataset is a panel where each NUTS-2 region $i \in \{1, .., 223\}$ is observed at time $t$, where $t \in \{2007, ..., 2014\}$. Our baseline model is the following:

$$
\begin{aligned}
pvt_{i,t} = \quad & \alpha_1 pvt_{i,t-1} + \alpha_2 eif_{i,t-1} + \alpha_3 eif_{i,t-2} + \alpha_4 eif_{i,t-3} \\
& + \alpha_5 educ_{i,t-1} + \alpha_6 unemp_{i,t-1} + \alpha_7 empdens_{i,t-1} \\
& + \alpha_8 eif_{i,t-1} \times educ_{i,t-1} + \alpha_9 eif_{i,t-1} \times unemp_{i,t-1} + \alpha_{10} empdens_{i,t-1} \times unemp_{i,t-1} \\
& + eif_{i,t-1} \times MACROREG_i \underline{\delta} + YEAR_t \underline{\lambda} + \eta_i + \epsilon_{i,t}
\end{aligned} \tag{1}
$$

where $pvt_{i,t}$, *private investment*, is the regional amount of VC market investments minus the EIF provided capital observed at time $t$. This variable represents the VC ecosystem in our model. Variable $eif_{i,t-1}$ and further lags are the amount of EIF investments, as defined in section 4.2, measured in region $i$ in the previous years. The control variables $educ$, $unemp$ and $empdens$ represent, respectively, the share of regional population that has attained tertiary education (*i.e.* a bachelor, master or PhD degree, or any certificate with ISCED 2011 level above 5), the unemployment rate and the employment density (*i.e.* workers/square km), all sourced from Eurostat. All these variables, with the exception of $unemp$, are expressed in natural logarithm. $MACROREG_i$ is a set of 5 dummy vari-

[51] Note that the kurtosis for a standard normal distribution is 3.

Figure 10: VC Investment in the key regional hubs (2007-2014)




Note: A NUTS2 region is classified as a hub when its investment level times the number of investments ranks in the top 10% of the cross-regional distribution for 3 consecutive years. All monetary values are expressed at constant prices (2005 = 100). Source: Invest Europe (2016), authors.

ables out of the 6 EU macro-regions introduced in section 3,[52] capturing effects related to common area-specific shocks. Moreover, $YEAR_t$ is a set of time dummies used to control for all the possible year-specific effects related to the economic cycle that can affect our dependent variable.[53] As for the last two terms, $\eta_i$ is a region-specific fixed effect that retains all the time invariant features of the specific regions (*e.g.* social, cultural, institutional factors characterising the regions, fixed in the short term). Instead, $\epsilon_{i,t}$ is a potentially heteroskedastic and serially correlated idiosyncratic shock, that we assume being uncorrelated across regions[54] (*i.e.* $cov(\epsilon_{i,t}\epsilon_{j,t}) = 0$, $\forall i, j$ with $i \neq j$).

As well documented in the literature, the OLS approach provides inconsistent estimates of the parameters of interest when the dependent and at least one of the explicative variables is affected by simultaneity (*i.e.*, reverse causality). Granted that the size of the EIF investments will depend on the current and past activity of the VC market, OLS parameter estimates will be inconsistent in our framework. Also, the dynamic nature of our model specification, *i.e.* having a lagged value of the dependent variable as a regressor, hinders the consistency of standard panel data estimators when the number of years $T$ in the panel is "small", as in our case. Therefore, in order to estimate model (1), we adopt specific GMM dynamic panel estimators that make use of instrumental variables[55] to address the endogeneity induced by simultaneity and dynamic panel biases. In particular, we employ the Arellano-Bond and the Blundell-Bond estimators, also known as, respectively, Difference-GMM and System-GMM. Technical details on the rationale, the main assumptions behind and the way these estimators are used can be found in the appendix.

Against this background, we first estimate the model (1) using OLS and Within Group Fixed Effects (FE) estimation, aware that these two approaches provide inconsistent estimates of the parameters of interest. Nevertheless, there is value in verifying the upward and downward bias in the estimation of $\alpha_1$ brought by OLS and FE respectively (see appendix H). Indeed, they provide an ideal range for the true value of $\alpha_1$. An estimated value of the auto-regressive term's coefficient within this interval is *de facto* a good signal of bias reduction (Bond, 2002; Roodman, 2006).

### 4.4 Empirical Evidence

Table 3 shows the results for all the estimated models. Pooled OLS with standard errors clustered at regional level yields negative and not significant coefficient for the first lag of EIF investments, while the estimated parameter associated to its third lag is positive and significant. The same patterns can be found when estimating the model with a general Fixed Effect panel estimator. Note that the coefficient of the interaction term of EIF investments and educational achievement is positive and not significant. Shifting to GMM estimators dramatically changes the model outcome.

52 The baseline level for this variable is the British Isles (BI) macro-region. For the composition of regions refer to footnote 33.

53 In order to control for macroeconomic effects, we also employed the real GDP per capita and the real gross fixed capital formation (*i.e.*, investment) in the model specification. Notwithstanding, the associated coefficients always turn out to be highly insignificant, after controlling for time and region effects

54 This is a strong assumption that we keep throughout the analysis, although the extent to which it holds true should be clearly assessed in future endeavours.

55 In this framework, the instrumental variables used are all "internal", *i.e.* based on lags of the instrumented endogenous variables.

Table 3: Dynamic panel data model estimates. Dependent var.: $\ln$ (private investment$_t$)

| | (1) POLS | (2) FE | (3) DIFF-GMM | (4) SYS-GMM |
|---|---|---|---|---|
| $\ln$ (Pvt Investment$_{t-1}$) | 0.5813*** | 0.0189 | 0.0580 | 0.1496*** |
| | (0.040) | (0.045) | (0.063) | (0.055) |
| $\ln$ (EIF Inv.$_{t-1}$) $^{\dagger}$ | -0.1444 | -0.1465 | 2.6762** | 1.4116* |
| | (0.225) | (0.454) | (1.315) | (0.821) |
| $\ln$ (EIF Inv.$_{t-2}$) | 0.0124 | -0.0317 | -0.1862* | -0.1241 |
| | (0.035) | (0.030) | (0.103) | (0.091) |
| $\ln$ (EIF Inv.$_{t-3}$) | 0.1176*** | 0.0449* | 0.1004* | 0.0899** |
| | (0.028) | (0.024) | (0.055) | (0.044) |
| Educational Level$_{t-1}$ | 1.3767* | -0.8917 | 6.9865 | 6.0255* |
| | (0.724) | (2.993) | (6.678) | (3.127) |
| Unemp. rate$_{t-1}$ | -0.1377 | 0.0192 | 0.2373 | -0.3031 |
| | (0.095) | (0.261) | (0.365) | (0.307) |
| Empl. density$_{t-1}$ | -0.1581 | 3.7894 | 9.6173 | 0.2258 |
| | (0.182) | (5.999) | (12.621) | (1.606) |
| $\ln$ (EIF Inv.$_{t-1}$) $\times$ Educational Level$_{t-1}$ | 0.0497 | 0.0807 | -0.7886** | -0.3682 |
| | (0.068) | (0.135) | (0.380) | (0.239) |
| $\ln$ (EIF Inv.$_{t-1}$) $\times$ Unemp. rate$_{t-1}$ | -0.0018 | -0.0081 | 0.0275 | 0.0183 |
| | (0.005) | (0.007) | (0.017) | (0.014) |
| Unemp. rate$_{t-1}$ $\times$ Empl. density$_{t-1}$ | 0.0305 | 0.0077 | -0.0861 | 0.0313 |
| | (0.022) | (0.062) | (0.072) | (0.079) |
| Obs. | 1,551 | 1,551 | 1,328 | 1,551 |
| F-Test (p-value) | | | 0.019 | 0.000 |
| Hansen (p-value) | | | 0.693 | 0.229 |
| AB AR(2)(p-value) | | | 0.163 | 0.613 |
| Number of Instruments | | | 170 | 184 |
| Year FE | Yes | Yes | Yes | Yes |
| $\ln$ (EIF Inv.$_{t-1}$) $\times$ Macro-Reg FE | Yes | Yes | Yes | Yes |

* p<0.10, ** p<0.05, *** p<0.01. Standard errors in parentheses. $^{\dagger}$ This is a *conditional effect*: see appendix H

Note: both DIFF-GMM and SYS-GMM are *two-step* estimates. The Windmeijer standard errors correction has been applied. Instrument matrix has been collapsed using the *collapse* option available in Stata's *xtabond2* (Roodman, 2006).

Columns (3) and (4) of Table 3 present the estimates from dynamic panel GMM estimators. The coefficients of the auto-regressive term lie within the OLS-FE interval for both Difference and System GMM, hinting at the dynamic panel bias being reduced by the use of consistent estimators. The average marginal effect of the first lag of EIF investment is positive but not significant when using DIFF-GMM and SYS-GMM estimators.[56] Using the DIFF-GMM approach, we find that EIF investments have a negative and significant effect on the VC ecosystem after two years, although its significance is not confirmed by the SYS-GMM framework. Quite consistent across various model specifications is the positive and significant effect of the third lag of EIF investments, suggesting that a crowding-in effect, if there at all, may be linked to medium- or long-term dynamics.

Furthermore, DIFF-GMM displays an interesting negative and significant effect of the interaction term between EIF investments and educational achievement. According to this, the positive impact of EIF investments on activity volumes one year later is higher in regions with lower tertiary education, compared to regions with an high share of skilled population. Given the well known positive correlation

[56] Due to the model specification in (1), the average marginal effect (*i.e.* the unconditional effect) of $\ln$ (EIF Inv.$_{t-1}$) is not directly available in Table 3. Refer to appendix H for its full derivation.

between human capital and venture capital market development (Martin *et al.*, 2002), this estimated effect suggests that EIF may be having a role in fostering the development of a VC ecosystem in regions lacking an adequate level of skills and risk capital investments. The interaction effect is also negative but not statistically significant for the SYS-GMM estimator. However, the SYS-GMM estimator yields a positive and statistically significant main effect for the level of tertiary education, confirming the link between this variable and the general VC financing in the year thereafter.

Overall, the data rule out the "crowding-out" argument for EIF investments: no significantly negative effect is linked to lagged EIF investments. In fact, the SYS-GMM estimates show that a 1% increase in the EIF share of EIF-backed VC investments in year $t$ led, on average, to a 0.89% increase in the VC ecosystem investment volumes in the region in year $t + 3$.[57] In conclusion, while no "crowding-out" brought by EIF investments is observed, the data points instead to a potential *crowding-in* effect, prompted by EIF intervention on the European venture capital market in the 2007-2014 period.

## 4.5 Robustness, limitations and possible extensions

We now outline some technical aspects in support of the results described in section 4.4. The Hansen test of over-identifying restrictions does not reject the null hypothesis of joint validity of the instruments for both DIFF-GMM and SYS-GMM. As the Hansen test is weakened by the presence of many instruments, for each model estimate we report the number of instruments used. In appendix I, we show how the coefficient estimates for $\ln(\text{EIF Inv.}_{t-s})$, $s = 1, 2, 3$ and the p-value of the Hansen test vary according to the number of instruments in the GMM instrument matrix.[58] Also, we check for the presence of auto-correlation in the estimated residuals by means of the Arellano-Bond auto-correlation test. The test assumes no second-order auto-correlation in the first-differenced residuals.[59] The rejection of the test null hypothesis hints at specification issues in the model, given that a correct model specification and GMM estimation should provide i.i.d.[60] estimated residuals (Arellano and Bond, 1991). In our case, for both DIFF-GMM and SYS-GMM, the absence of auto-correlation in the estimated residuals in levels is not rejected, hinting to a correct model specification.

Assessing which of the two GMM estimators is preferred in a specific application is not straightforward. In principle, if 1) the series within the model display unit-root or near-unit-root behavior and 2) we assume that the unobserved fixed effects are systematically uncorrelated with the deviations of the instrumenting variables from their steady state values, then System GMM allows a drastic improvement in efficiency. As for the series persistency, nonstationarity is rejected by dynamic panel

[57] Since data are expressed in natural logs, the coefficient estimates represent average elasticities.

[58] The maximum number of lags of endogenous variables used in the instrument matrix is 16, *i.e.* for all the variables with the exception of $pvt$ we use all the information available from 1997 onward in building parameter estimates. As documented in Roodman (2006), the use of too many instruments can be harmful. Therefore, as a robustness check, we study the behavior of the SYS-GMM estimator, that we take as a benchmark, when the number of instruments used varies.

[59] If the first-differenced estimated residuals follow an $AR(2)$ process, then the residuals in levels display first-order auto-correlation. For further, see Arellano and Bond (1991).

[60] Independently and identically distributed.

unit-root tests.[61] Moreover, the underlying assumption that changes in the instrumenting variables (*i.e.*, our endogenous regressors) are uncorrelated with the fixed effects requires that, controlling for the covariates, faster-growing regions are not systematically closer or farther from their steady states than slower-growing ones (Roodman, 2006). The extent to which this assumption holds in our context is unclear and impossible to test. On the other hand, as can be observed in Table 3, standard errors estimated with System GMM are systematically lower than Difference-GMM ones, suggesting an effective improvement in efficiency. Also, the coefficient of the auto-regressive term $pvt_{i,t-1}$ is statistically strongly significant, a feature that a good dynamic model estimate should provide, if there is a true underlying dynamic process. Against this background, we provide estimates using both approaches, even if, for the reasons explained above, we consider SYS-GMM as the benchmark among all the estimated models.

There are a few limitations that should be kept in mind when interpreting our results. First, as outlined in section 4.3, a key assumption is that the error term is correlated within regions, but not across them. Can we rule out the presence of regional spillovers and spatial proximity dynamics when considering neighboring regions? Special weights for the covariance matrix must be adopted when spatial correlation occurs. Moreover, we observe a number of features in the VC investment distribution (see section 4.2) that warn us against blindly relying on average values. Alternative methodologies that account for heavy-tailed distribution should be tested in order to control for potential non-normality of the error term. We leave it to future research to address these important aspects.

## 5 Concluding remarks

In this paper, we analysed the spatial distribution of EIF-backed VC startups, illustrating the geographic breadth of EIF-supported venture capital while also highlighting areas of high concentration. Moreover, we performed a dynamic panel regression sought to estimate the impact of EIF-provided venture capital in the 2007-2014 period, observing that EIF VC activity did not *crowd-out* other VC investors, but if anything crowded them *in* instead. The reader is referred to the non-technical summary on page 6 for an overview of the main results.

We now conclude with an indication of our future work. As opposed to our first volume, mainly concerned with macro-level aspects of EIF VC activities, forthcoming issues will delve into the firm-level dynamics that characterise EIF-backed startups. To this end, we will focus on their growth performance, so as to trace different profiles of firm development. Moreover, we will address the topic of job creation, on the basis of data sourced from the balance sheets of EIF-backed startups. Additional topics for future issues concern exit performance, survivability and innovation. Future publications will address themes from a consistent economic perspective and with the goal to provide data-driven insights on the outcome of EIF VC activities. This work will pave the way to the final aim of this series: to assess whether the activity of EIF led to VC investments that positively affected the performance of the targeted startups.

[61] We have tested the stationarity of the $pvt$ series by means of the Harris-Tzavalis test (Harris and Tzavalis, 1999) that, conversely to standard unit-root tests (*i.e.*, Dickey-Fueller, Phillips-Perron), is particularly suited for "small $T$, large $N$" dynamic panels.

## References


AFME and BCG (2015). Bridging the growth gap - investor views on European and US capital markets and how they drive investment and economic growth. Report, Association for Financial Markets in Europe. URL http://www.afme.eu/funding-economy/.

Akerlof, G. (1970). The market for lemons: Quality uncertainty and the market mechanism. *Quarterly Journal of Economics*, vol. 89, no. 3, pp. 488–500.

Anderson, T.W. and Hsiao, C. (1981). Estimation of dynamic models with error components. *Journal of the American statistical Association*, vol. 76, no. 375, pp. 598–606.

Angrist, J.D. and Pischke, J.S. (2008). *Mostly harmless econometrics: An empiricist's companion*. Princeton university press.

Arellano, M. and Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, vol. 58, no. 2, pp. 277–297.

Arellano, M. and Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, vol. 68, no. 1, pp. 29–51.

Arrow, K. (1985). The economics of agency. In K. Arrow, editor, *Principals and Agents: The Structure of Business*. Harvard Business School Press, Boston, MA.

Aubrey, T., Thillaye, R. and Reed, A. (2015). *Supporting investors and growth firms: A bottom-up approach to a Capital Markets Union*. Policy Network and Rowman & Littlefield International.

Bertoni, F. and Martí, J. (2011). Financing entrepreneurial ventures in europe: The VICO dataset. Working paper 1904297, Social Science Research Network (SSRN).

Bertoni, F. and Tykvová, T. (2012). Which form of venture capital is most supportive of innovation? Discussion paper, ZEW-Centre for European Economic Research.

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, vol. 87, no. 1, pp. 115–143.

Bond, S.R. (2002). Dynamic panel data models: a guide to micro data methods and practice. *Portuguese Economic Journal*, vol. 1, no. 2, pp. 141–162.

Bottazzi, L., Da Rin, M. and Hellmann, T. (in press). The importance of trust for investment: Evidence from venture capital. *The Review of Financial Studies*. Accepted manuscript.

Brander, J.A., Du, Q. and Hellmann, T. (2015). The effects of government-sponsored venture capital: international evidence. *Review of Finance*, vol. 19, no. 2, pp. 571–618.

Brophy, T.S., Daniels, R.C. and Musundwa, S. (2015). gpsbound: A command for importing and verifying geographical information from a user-provided shapefile. *Stata Journal*, vol. 15, no. 2, pp. 523–536.

Canova, F. and Ciccarelli, M. (2013). Panel vector autoregressive models: A survey. Tech. Rep. 1507, ECB. Working paper.

CBInsights (2014). The next silicon valley. URL www.cbinsights.com/blog/next-silicon-valley-data, [Online; accessed 28-April-2016].

Colombo, M.G., Cumming, D.J. and Vismara, S. (2014). Governmental venture capital for innovative young firms. *The Journal of Technology Transfer*, vol. 41, pp. 10–24.

Davila, A., Foster, G. and Gupta, M. (2003). Venture capital financing and the growth of startup firms. *Journal of Business Venturing*, vol. 18, no. 6.

Ellison, G. and Glaeser, E.L. (1994). Geographic concentration in U.S. manufacturing industries: a dartboard approach. Working Paper 4840, National Bureau of Economic Research. URL http://www.nber.org/papers/w4840.

——— (1999). The geographic concentration of industry: does natural advantage explain agglomeration? *The American Economic Review*, vol. 89, no. 2, pp. 311–316.

Ernst & Young (2015). Für junge firmen sind nur zwei städte cool genug. URL www.welt.de/wirtschaft/article136076761/Fuer-junge-Firmen-sind-nur-zwei-Staedte-cool-genug.html, [Online; accessed 28-April-2016].

Florida, R.L. and Kenney, M. (1988). Venture capital, high technology and regional development. *Regional Studies*, vol. 22, no. 1, pp. 33–48.

Florida, R.L. and King, M.K. (2016). Rise of the global startup city: the geography of venture capital investment in cities and metros across the globe. Tech. rep., Martin Prosperity Institute.

Frontier Economics (2013). Exploring the impact of private equity on economic growth in Europe. Tech. rep., EVCA (now Invest Europe).

Glaeser, E.L., Kerr, W.R. and Ponzetto, G.A. (2010). Clusters of entrepreneurship. *Journal of Urban Economics*, vol. 67, no. 1, pp. 150–168.

Glaeser, E.L. and Resseger, M.G. (2010). The complementarity between cities and skills. *Journal of Regional Science*, vol. 50, no. 1, pp. 221–244.

GSA (2015). European startup monitor. Tech. rep., German Startup Association. URL http://europeanstartupmonitor.com/esm/esm-2015/.

Hansen, L.P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica: Journal of the Econometric Society*, vol. 50, no. 4, pp. 1029–1054.

Harris, R.D. and Tzavalis, E. (1999). Inference for unit roots in dynamic panels where the time dimension is fixed. *Journal of econometrics*, vol. 91, no. 2, pp. 201–226.

Hellmann, T.F., Schure, P. and Vo, D. (2015). Angels and venture capitalists: Substitutes or complements? Working Paper 2, Saïd Business School.

Holtz-Eakin, D., Newey, W. and Rosen, H.S. (1988). Estimating vector autoregressions with panel data. *Econometrica: Journal of the Econometric Society*, vol. 56, no. 6, pp. 1371–1395.

Jaffee, D.M. and Russell, T. (1976). Imperfect information, uncertainty, and credit rationing. *The Quarterly Journal of Economics*, vol. 90, no. 4, pp. 651–666.

Kelly, R. (2011). The performance and prospects of European Venture Capital. EIF Working Paper 2011/9, EIF Research & Market Analysis.

Kraemer-Eis, H., Lang, F. and Gvetadze, S. (2013). European small business finance outlook, December 2013. EIF Working Paper 2013/20, EIF Research & Market Analysis.

——— (2015). European small business finance outlook, December 2015. EIF Working Paper 2015/32, EIF Research & Market Analysis.

Lerner, J. (2002). When bureaucrats meet entrepreneurs: the design of effective 'public venture capital' programmes. *The Economic Journal*, vol. 112, no. 477, pp. F73–F84.

——— (2009). *Boulevard of broken dreams: why public efforts to boost entrepreneurship and venture capital have failed–and what to do about it*. Princeton University Press.

Lerner, J., Pierrakis, Y., Collins, L. and Bravo Biosca, A. (2011). Atlantic drift: venture capital performance in the UK and the US. URL http://www.nesta.org.uk/publications/atlantic-drift.

Leslie, A.J. and Wells, P.C. (2000). The determinants of venture capital funding: evidence across countries. *Journal of Corporate Finance*, vol. 6, no. 3.

Marshall, A. (1890). *Principles of Economics*. Macmillan and Co., London, 1 ed.

Martin, R., Sunley, P. and Turner, D. (2002). Taking risks in regions: the geographical anatomy of Europe's emerging venture capital market. *Journal of Economic Geography*, vol. 2, no. 2, pp. 121–150.

Mason, C. (2012). Venture capital: a geographical perspective. In C. Mason *et al.*, editors, *Handbook of research on venture capital*, chap. 3, pp. 86–112. Edward Elgar Publishing.

Mitchell, T.D., Carter, T.R., Jones, P.D., Hulme, M. and New, M. (2003). A comprehensive set of high-resolution grids of monthly climate for europe and the globe: the observed record (1901–2000) and 16 scenarios (2001–2100). Working Paper 55, Tyndall centre for climate change research.

Munari, F. and Toschi, L. (2015). Assessing the impact of public venture capital programmes in the United Kingdom: Do regional characteristics matter? *Journal of Business Venturing*, vol. 30, no. 2, pp. 205–226.

NESTA (2015). Methodology for constructing the european digital city index. Tech. rep., NESTA. URL https://digitalcityindex.eu/methodology.

Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica: Journal of the Econometric Society*, vol. 49, no. 6, pp. 1417–1426.

——— (1986). Dynamic models of labour demand. In D. Card and O. Ashenfelter, editors, *Handbook of Labor Economics*, chap. 9, pp. 473–522. North-Holland.

OECD (2006). The SME financing gap: Theory and evidence. *Financial Market Trends*, vol. 2006, no. 2.

Ozimek, A., Miles, D. *et al.* (2011). Stata utilities for geocoding and generating travel time and travel distance information. *Stata Journal*, vol. 11, no. 1, p. 106.

Pisati, M. (2007). SPMAP: Stata module to visualize spatial data. Stata Help Files. URL https://ideas.repec.org/c/boc/bocode/s456812.html.

Roodman, D. (2006). How to do xtabond2: An introduction to difference and system GMM in Stata. Working Paper 103, Center for Global Development.

——— (2009). A note on the theme of too many instruments. *Oxford Bulletin of Economics and Statistics*, vol. 71, no. 1, pp. 135–158.

Sorenson, O. and Stuart, T.E. (2001). Syndication networks and the spatial distribution of venture capital investments. *American Journal of Sociology*, vol. 106, no. 6, pp. 1546–1588.

Soto, M. *et al.* (2009). System GMM estimation with a small sample. Working paper, Barcelona Graduate School of Economics.

Stiglitz, J. and Weiss, A. (1981). Credit rationing in markets with imperfect information. *American Economic Review*, vol. 71, no. 3, pp. 393–410.

Sunley, P., Klagge, B., Berndt, C. and Martin, R. (2005). Venture capital programmes in the UK and Germany: in what sense regional policies? *Regional Studies*, vol. 39, no. 2, pp. 255–273.

Tykvová, T., Borell, M. and Kroencke, T. (2012). Potential of venture capital in the european union. Tech. rep., Directorate-General for Internal Policies, European Parliament. URL http://www.europarl.europa.eu/studies.

Unquote Intelligence (2006). The role of public funding bodies in european venture capital. Report Q2, Unquote.

Wilson, K.E. (2015a). How to unleash the financing of high growth firms in Europe: 10 recommendations for catalysing growth. Bruegel blog. [Online; accessed 27-May-2015].

——— (2015b). Policy lessons from financing innovative firms. *OECD Science, Technology and Industry Policy Papers*, vol. 24.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, vol. 126, no. 1, pp. 25–51.

# Appendices

## A Screening of seed and start-up companies

In this appendix, we list the assumptions used in the identification of first invested start-ups. A first assumption pertains to the start-up's age at first investment date:

**Assumption 1.** *Seed* and *start-up* investments reach companies incorporated for less than 10 years.

While assumption 1 may seem overly rigid with respect to very specific areas of venture capital financing,[62] it proves to be a widespread metric to identify VC-backed startups, for instance in Bertoni and Martí (2011) in the context of the VICO project, and more recently in the first European Startup Monitor (GSA, 2015). However, we consider assumption 1 not per se sufficient to discern early stage from later stage investments. We therefore include two additional assumptions:

**Assumption 2.** *Seed* and *start-up* investments target companies reporting no positive turnover in the 2 years preceding investment date.

Assumption 2 pertains to the general definition of seed and start-up investments. Although this may vary across different sources,[63] the relevant scientific literature converges towards the principle that seed and start-up investments, often grouped together in the "early stage" bracket, target companies that, in their most advanced state, *"are gearing up to produce, market, and sell their products"* (Leslie and Wells, 2000, p. 243). The cut-off moment seems thus to be the generation of the first commercial returns, for which our assumption aims at accounting for. Finally, we impose a third assumption, this time aimed at invested companies' size:

**Assumption 3.** *Seed* and *start-up* investments target companies with less than 250 employees at investment date.

Many reports and studies show that 250 is already an unrealistic upper-bound for headcount levels in seed and start-up companies (see for instance Davila *et al.* 2003, p. 696). However, this relatively high threshold reflects the notion that start-up companies constitute a subset of the broader SME category, the overarching target group of EIF-managed programmes.

The joint ascertainment of assumption 1 and one or both assumptions 2-3 classifies EIF-backed VC companies in our original dataset as "true" seed and start-up first-invested companies.[64] For a small portion of our dataset, data availability issues prevent us from verifying assumption 2 or 3: in such cases, we follow the "benefit-of-the-doubt" approach and count the underlying companies as first-invested start-ups.

[62] In particular in the life science category, where the gestation period before product commercialisation can occasionally overcome this arbitrary time limit.

[63] For instance, Invest Europe definition of start-up financing excludes that targeted companies generate commercial return, while the definition adopted by the European Startup Monitor includes companies that already generate their first revenue.

[64] In a final separated step, we discard an additional small number of companies that have reportedly obtained VC investments prior to the EIF-backed first investment date, according to a specialised information source.

## B Determinants of hub proximity

Dependent variable: log of geodetic distance between startup and closest hub

| | OLS | Tobit | Quantile 0.25 | Quantile 0.5 | Quantile 0.75 |
|---|---|---|---|---|---|
| **Startup attributes:** | | | | | |
| Investment period: 1996-2001† | -0.2630 | -0.4150* | 0.0000 | -0.4458* | -0.2263* |
| | (0.164) | (0.241) | (0.000) | (0.248) | (0.132) |
| Investment period: 2008-2014† | -0.6481*** | -1.3010*** | 0.0000 | -1.5396*** | -0.4851*** |
| | (0.198) | (0.247) | (0.000) | (0.366) | (0.168) |
| Industry: Life Sciences† | 0.5985*** | 1.0749*** | 0.0000 | 1.1632*** | 0.4404*** |
| | (0.227) | (0.221) | (0.000) | (0.332) | (0.130) |
| Industry: Manufacturing† | 1.4338*** | 2.5015*** | 2.5768*** | 2.1600*** | 0.5250*** |
| | (0.197) | (0.436) | (0.646) | (0.476) | (0.197) |
| Industry: Services† | -0.3209 | -0.6983** | 0.0000 | -0.3256 | -0.1047 |
| | (0.201) | (0.317) | (0.000) | (0.225) | (0.248) |
| Industry: Green Technologies† | 1.2357*** | 2.2225*** | 0.0000 | 3.0866*** | 1.0146*** |
| | (0.442) | (0.535) | (0.836) | (0.639) | (0.378) |
| **Investment attributes:** | | | | | |
| Log of total invested amount | -0.0000 | -0.0000* | 0.0000 | -0.0000 | 0.0000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **Geographical attributes:** | | | | | |
| Log of urban area in startup's country | 0.2045*** | 0.3814*** | 0.0000 | 0.1083 | 0.4958*** |
| | (0.078) | (0.084) | (0.000) | (0.092) | (0.088) |
| Average annual temperature | -0.1025** | -0.2565*** | 0.0000 | -0.0323 | -0.2212*** |
| in startup's country | (0.048) | (0.073) | (0.000) | (0.055) | (0.064) |
| **VC firm attributes:** | | | | | |
| VC firm located in a hub a† | -1.0091*** | -1.6822*** | 0.0000 | -2.0119*** | -0.6880*** |
| | (0.222) | (0.244) | (0.442) | (0.331) | (0.154) |
| Constant term | 1.8906 | 0.1693 | 0.0000 | 2.9229** | 1.8979** |
| | (1.149) | (1.166) | (0.442) | (1.443) | (0.814) |
| Startup stage[b] | Yes | Yes | Yes | Yes | Yes |
| Startup location (macro-region)[c] | Yes | Yes | Yes | Yes | Yes |
| Startup age at first investment | Yes | Yes | Yes | Yes | Yes |
| Nr. of observations | 2419 | 2432 | 2432 | 2432 | 2432 |
| $R^2$ [Pseudo $R^2$] | 0.14 | [0.05] | 0.01 | 0.16 | 0.11 |

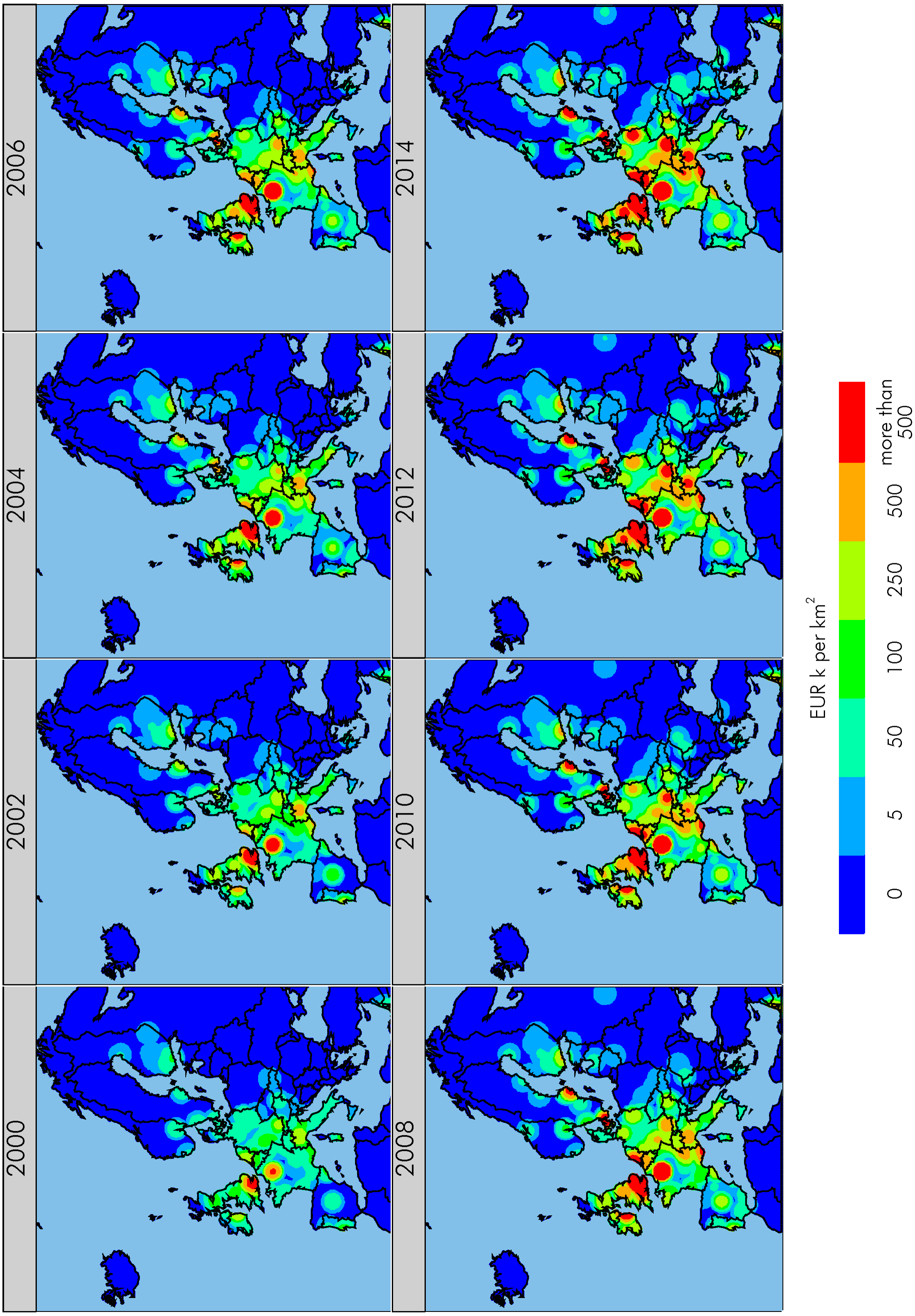
* p<0.10, ** p<0.05, *** p<0.01; [a] For a list of the European hubs considered refer to footnote 30; [b] Investment stages: *seed* (baseline), *start-up*, *other early stage*; [c] For the composition of regions refer to footnote 33; † Dichotomic variable.

Notes on the analysis: source data are EIF-supported startups that have been geolocated (initial sample size: 2,666). Only startups located in Europe were used in the analysis. Startups invested by angel investors were further excluded.

The models are estimated on the logarithms of the geodetic distance (measured in km), given the high skewness of the dependent variable. As distances are based on the coordinates of headquarters' cities, we set $log(\text{distance}) = 0$ if distance $= 0$ in order to include startups located in hubs (without a particular loss of precision). The base level for the set of *Investment period* dummies is the period 2002-2007, while the base level for *Industry* dummies is ICT. All monetary values are expressed in 2005 prices. The source of national urban area extension is Eurostat, while temperature data was retrieved from Mitchell *et al.* (2003).

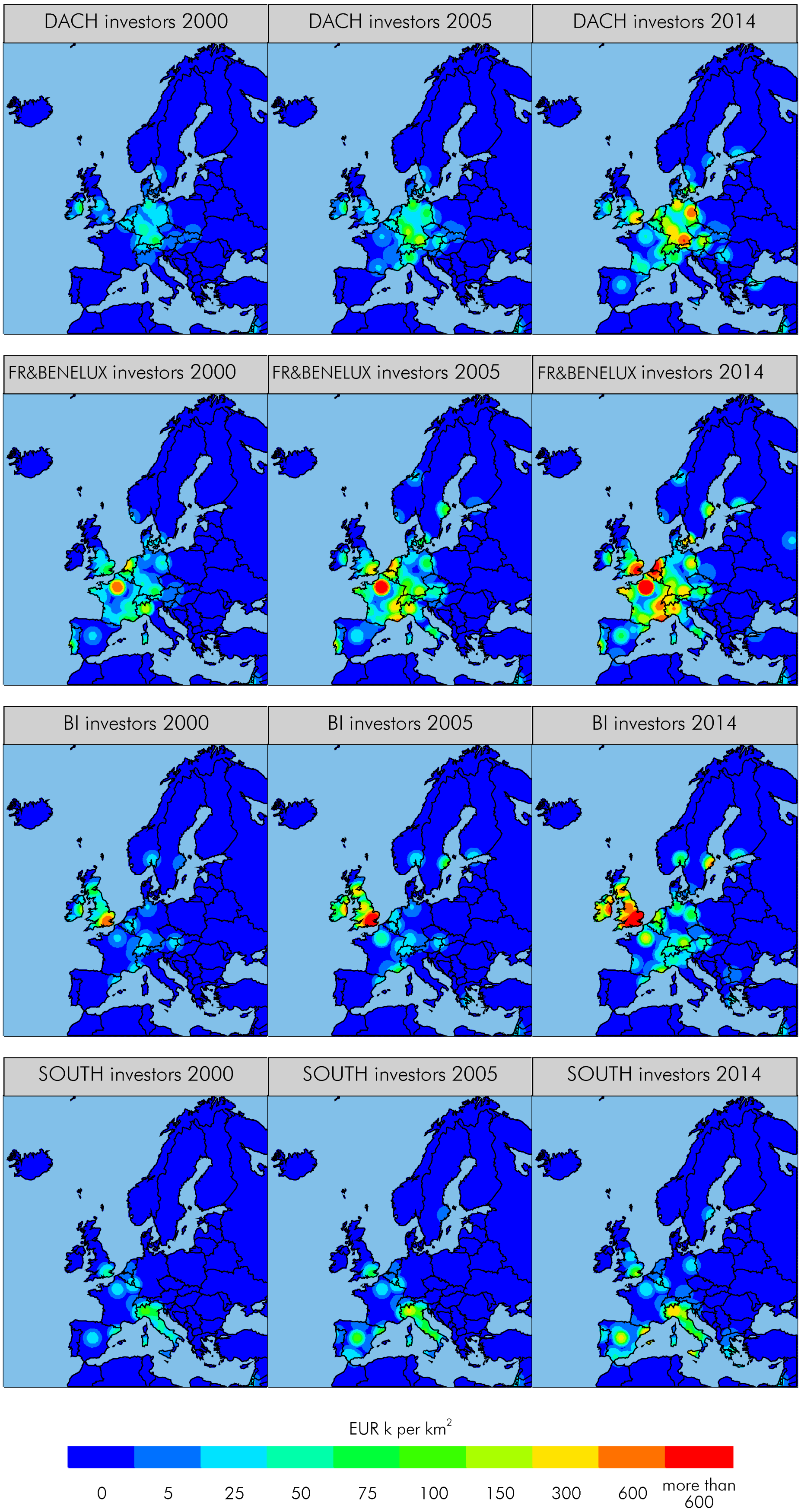
The OLS and Tobit models are estimated using clustered standard errors at VC firm level. As per the quantile regression models, we computed our estimates by means of simultaneous-quantile regression. Standard errors for quantile regressions were computed via bootstrapping with 500 replications. The model's robustness has been assessed via the addition and removal of several alternative variables (e.g. log of national VC market activity, which is never significant). The R-squared and pseudo R-squared statistics are reported for completeness: due to the different estimation techniques employed in the analysis, these values should not be considered as comparable.

## C Spatial dispersion of EIF-backed investments over time

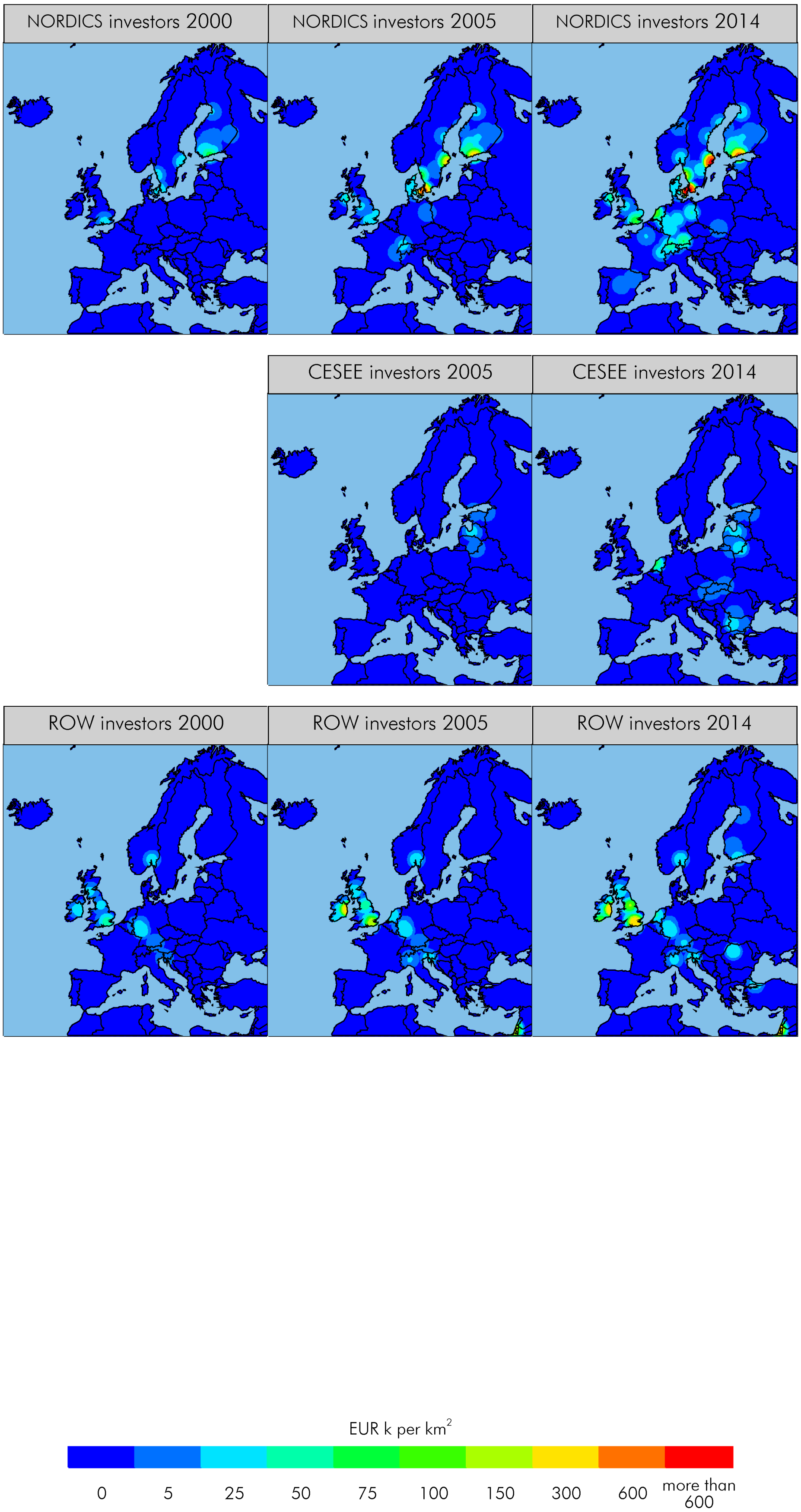



Cumulated investment density in 2005 prices.

## D Spatial dispersion of EIF-backed investments by origination area and year




Note: Cumulated amounts, expressed in 2005 prices.




Note: Cumulated amounts, expressed in 2005 prices.

## E Determinants of investment proximity

Dependent variable: log of geodetic distance between VC firm and start-up company

| | OLS | Tobit | Quantile 0.25 | Quantile 0.65 | Quantile 0.95 |
|---|---|---|---|---|---|
| **Investor attributes:** | | | | | |
| First time investor team† | -0.2135 | -0.2627 | 0.0000 | -0.1549 | 0.0119 |
| | (0.229) | (0.330) | (0.078) | (0.143) | (0.086) |
| Log of VC fund size at closing date | 0.2432** | 0.3147* | -0.0000 | 0.1658*** | 0.0754* |
| | (0.122) | (0.171) | (0.121) | (0.053) | (0.042) |
| VC firm located in a hub [a]† | -0.7012*** | -1.0291*** | -1.9489*** | 0.1126 | -0.1693 |
| | (0.263) | (0.357) | (0.548) | (0.110) | (0.114) |
| **Investment attributes:** | | | | | |
| Log of total invested amount | 0.0468 | 0.0679 | 0.0000 | 0.0229 | 0.0066 |
| | (0.041) | (0.061) | (0.015) | (0.017) | (0.016) |
| Investment period: 1996-2001† | -0.2852* | -0.4369** | -0.7718 | -0.0153 | 0.0241 |
| | (0.157) | (0.204) | (0.470) | (0.078) | (0.057) |
| Investment period: 2008-2014† | -0.6186*** | -0.9521*** | -0.7718 | -0.0981 | 0.1439 |
| | (0.179) | (0.258) | (0.543) | (0.080) | (0.112) |
| **Market environment:** | | | | | |
| Log of national VC market activity [b] | 0.0312 | 0.0770** | -0.0000 | -0.0000 | -0.0142 |
| | (0.021) | (0.036) | (0.001) | (0.002) | (0.013) |
| Constant term | -0.4441 | -2.8338 | 2.7208 | 2.8705*** | 6.3792*** |
| | (2.275) | (3.316) | (2.218) | (0.980) | (0.882) |
| Fund stage focus | Yes | Yes | Yes | Yes | Yes |
| Fund sector focus | Yes | Yes | Yes | Yes | Yes |
| Fund location (macro-region) [c] | Yes | Yes | Yes | Yes | Yes |
| Fund geographic focus | Yes | Yes | Yes | Yes | Yes |
| Nr. of observations | 2806 | 2806 | 2820 | 2820 | 2820 |
| $R^2$ [Pseudo $R^2$] | 0.23 | [0.06] | 0.14 | 0.16 | 0.23 |

* $p<0.10$, ** $p<0.05$, *** $p<0.01$; [a] For a list of the European hubs considered refer to footnote 30;
[b] Source: Invest Europe's country industry statistics, VC only. [c] For the composition of regions refer to footnote 33.

**Notes on the analysis:** Models estimated on data related to investments to all geolocated startups (initial sample size: 3,083). 263 investments were dropped from the analysis for a lack of respective market activity data.

The models are estimated on the logarithms of the geodetic distance (measured in km), given the high skewness of the dependent variable. As distances are based on the coordinates of headquarters' cities, we set $log(\text{distance}) = 0$ if distance $= 0$ in order to include within-city investments (without a particular loss of precision). Moreover, the variable *Fund geographic focus*, defining the *ex-ante* investment geographic preference of funds, was imputed for 58 funds by looking at the *ex-post* investment distribution (results do not change significantly if these observations are dropped). The mark † indicates dichotomic variables (all additional fund-level controls are categorical variables). The base level for the set of *Investment period* dummies is the period 2002-2007. All monetary values are expressed in 2005 prices.

The OLS and Tobit models are estimated using clustered standard errors at VC firm level. As per the quantile regression models, we computed our estimates by means of simultaneous-quantile regression. The choice of the 65% and 95% quantiles instead of the more conventional 50% and 75% are made necessary given the distribution features of the dependent variable and the need to provide a sufficient number of observations for the maximisation algorithm to converge. Standard errors for quantile regressions were computed via bootstrapping with 500 replications.

The model's robustness has been assessed via the addition and removal of several alternative variables. Notably, variables related to the features of the investment (e.g. investment stage, startup's sector, location) are never significant if the model already controls for the fund's investment preferences. The R-squared and pseudo R-squared statistics are reported for completeness: due to the different estimation techniques employed in the analysis, these values should not be considered as comparable.

## F List of NUTS-2 regions included in the analysis

| Country code | NUTS-2 region |
|---|---|
| AT | Burgenland (AT11), Niederosterreich (AT12), Wien (AT13), Karnten (AT21), Steiermark (AT22), Oberosterreich (AT31), Salzburg (AT32), Tirol (AT33), Vorarlberg (AT34). |
| BE | Region de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest (BE10), Prov. Antwerpen (BE21), Prov. Limburg (BE22), Prov. Oost-Vlaanderen (BE23), Prov. Vlaams-Brabant (BE24), Prov. West-Vlaanderen (BE25), Prov. Brabant Wallon (BE31), Prov. Hainaut (BE32), Prov. Liege (BE33), Prov. Namur (BE35). |
| BG | Yugoiztochen (BG34), Yugozapaden (BG41), Yuzhen tsentralen (BG42). |
| CH | Region Lemanique (CH01), Espace Mittelland (CH02), Nordwestschweiz (CH03), Zurich (CH04), Ostschweiz (CH05), Zentralschweiz (CH06), Ticino (CH07). |
| CZ | Praha (CZ01), Jihozapad (CZ03), Jihovychod (CZ06). |
| DE | Stuttgart (DE11), Karlsruhe (DE12), Freiburg (DE13), Tubingen (DE14), Oberbayern (DE21), Niederbayern (DE22), Oberpfalz (DE23), Oberfranken (DE24), Mittelfranken (DE25), Unterfranken (DE26), Schwaben (DE27), Berlin (DE30), Brandenburg (DE40), Bremen (DE50), Hamburg (DE60), Darmstadt (DE71), Giessen (DE72), Kassel (DE73), Mecklenburg-Vorpommern (DE80), Braunschweig (DE91), Hannover (DE92), Luneburg (DE93), Weser-Ems (DE94), Dusseldorf (DEA1), Koln (DEA2), Munster (DEA3), Detmold (DEA4), Arnsberg (DEA5), Koblenz (DEB1), Rheinhessen-Pfalz (DEB3), Saarland (DEC0), Dresden (DED2), Chemnitz (DED4), Leipzig (DED5), Sachsen-Anhalt (DEE0), Schleswig-Holstein (DEF0), Thuringen (DEG0). |
| DK | Hovedstaden (DK01), Sjaelland (DK02), Syddanmark (DK03), Midtjylland (DK04), Nordjylland (DK05). |
| EE | Eesti (EE00). |
| EL | Kentriki Makedonia (EL12), Dytiki Ellada (EL23), Sterea Ellada (EL24), Attiki (EL30), Kriti (EL43). |
| ES | Galicia (ES11), Principado de Asturias (ES12), Cantabria (ES13), Pais Vasco (ES21), Comunidad Foral de Navarra (ES22), Aragon (ES24), Comunidad de Madrid (ES30), Castilla y Leon (ES41), Castilla-La Mancha (ES42), Extremadura (ES43), Cataluna (ES51), Comunidad Valenciana (ES52), Illes Balears (ES53), Andalucia (ES61). |
| FI | Lansi-Suomi (FI19), Helsinki-Uusimaa (FI1B), Etela-Suomi (FI1C), Pohjois- ja Ita-Suomi (FI1D). |
| FR | Ile de France (FR10), Champagne-Ardenne (FR21), Picardie (FR22), Haute-Normandie (FR23), Centre (FR24), Basse-Normandie (FR25), Bourgogne (FR26), Nord - Pas-de-Calais (FR30), Lorraine (FR41), Alsace (FR42), Franche-Comte (FR43), Pays de la Loire (FR51), Bretagne (FR52), Poitou-Charentes (FR53), Aquitaine (FR61), Midi-Pyrenees (FR62), Limousin (FR63), Rhone-Alpes (FR71), Auvergne (FR72), Languedoc-Roussillon (FR81), Provence-Alpes-Cote d'Azur (FR82). |
| HU | Kozep-Magyarorszag (HU10), Kozep-Dunantul (HU21), Del-Dunantul (HU23), Eszak-Alfold (HU32), Del-Alfold (HU33). |
| IE | Border, Midland and Western (IE01), Southern and Eastern (IE02). |
| IT | Piemonte (ITC1), Liguria (ITC3), Lombardia (ITC4), Campania (ITF3), Puglia (ITF4), Basilicata (ITF5), Sicilia (ITG1), Sardegna (ITG2), Veneto (ITH3), Friuli-Venezia Giulia (ITH4), Emilia-Romagna (ITH5), Toscana (ITI1), Marche (ITI3), Lazio (ITI4). |

*(continued)*

| Country code | NUTS-2 region |
|---|---|
| LT | Lietuva (LT00). |
| LU | Luxembourg (LU00). |
| LV | Latvija (LV00). |
| NL | Groningen (NL11), Friesland (NL12), Drenthe (NL13), Overijssel (NL21), Gelderland (NL22), Flevoland (NL23), Utrecht (NL31), Noord-Holland (NL32), Zuid-Holland (NL33), Zeeland (NL34), Noord-Brabant (NL41), Limburg (NL42). |
| NO | Oslo og Akershus (NO01), Sor-Ostlandet (NO03), Agder og Rogaland (NO04), Vest-landet (NO05), Trondelag (NO06), Nord-Norge (NO07). |
| PL | Mazowieckie (PL12), Malopolskie (PL21), Slaskie (PL22), Wielkopolskie (PL41), Dol-noslaskie (PL51), Pomorskie (PL63). |
| PT | Norte (PT11), Centro (PT16), Lisboa (PT17), Alentejo (PT18). |
| RO | Nord-Vest (RO11), Bucuresti - Ilfov (RO32), Sud-Vest Oltenia (RO41), Vest (RO42). |
| SE | Stockholm (SE11), Ostra Mellansverige (SE12), Smaland med oarna (SE21), Sydsverige (SE22), Vastsverige (SE23), Norra Mellansverige (SE31), Mellersta Norrland (SE32), Ovre Norrland (SE33). |
| SI | Zahodna Slovenija (SI04). |
| SK | Bratislavsky kraj (SK01), Zapadne Slovensko (SK02), Vychodne Slovensko (SK04). |
| UK | Tees Valley and Durham (UKC1), Northumberland and Tyne and Wear (UKC2), Greater Manchester (UKD3), Lancashire (UKD4), Cheshire (UKD6), Merseyside (UKD7), East York-shire and Northern Lincolnshire (UKE1), North Yorkshire (UKE2), South Yorkshire (UKE3), West Yorkshire (UKE4), Derbyshire and Nottinghamshire (UKF1), Leicestershire, Rutland and Northamptonshire (UKF2), Lincolnshire (UKF3), Herefordshire, Worcestershire and Warwickshire (UKG1), Shropshire and Staffordshire (UKG2), West Midlands (UKG3), East Anglia (UKH1), Bedfordshire and Hertfordshire (UKH2), Essex (UKH3), Inner London (UKI1), Outer London (UKI2), Berkshire, Buckinghamshire and Oxfordshire (UKJ1), Surrey, East and West Sussex (UKJ2), Hampshire and Isle of Wight (UKJ3), Kent (UKJ4), Glouces-tershire, Wiltshire and Bristol/Bath area (UKK1), Dorset and Somerset (UKK2), Cornwall and Isles of Scilly (UKK3), Devon (UKK4), West Wales and The Valleys (UKL1), East Wales (UKL2), Eastern Scotland (UKM2), South Western Scotland (UKM3), North Eastern Scotland (UKM5), Highlands and Islands (UKM6), Northern Ireland (UKN0). |

Note: For compatibility reason, region names in the table above are spelled without diacritics.

## G Variables used in the statistical analysis

| Variable | Model Label | Description | Level | Source |
|---|---|---|---|---|
| EIF Investment | $eif$ | Share of EIF-backed VC investments (early stage only) attributed directly to EIF, according to the EIF equity stake in the VC fund. | Regional (NUTS-2) | EIF (2015) |
| VC Mkt Investment | $pvt$ | Overall amount of venture capital investments (early and later stage) minus the EIF share of EIF-backed VC investments (early and later stage). | Regional (NUTS-2) | Invest Europe (2016), EIF (2015) |
| Employment Density | $empdens$ | Average number of workers / Square km | Regional (NUTS-2) | Eurostat (2016) |
| Educational Level | $educ$ | Share of total population (male and female) with tertiary educational attainment (ISCED 2011 levels 5-8). ISCED levels from 5 to 8 include: Short-cycle tertiary education, Bachelor's or equivalent, Master's or equivalent, Doctoral or equivalent. | Regional (NUTS-2) | Eurostat (2016) |
| Unemployment Rate | $unemp$ | Unemployed people as a percentage of the economically active population (*i.e.* labour force). It comprises persons aged 15-74 who were (all three conditions must be fulfilled simultaneously): 1. without work during the reference week, 2. currently available for work, 3. actively seeking work or who had found a job to start within a period of at most three months. | Regional (NUTS-2) | Eurostat (2016) |

## H Technical details of the econometric model

This appendix sheds light on the technical details of the estimations carried in section 4, their rationale and the main assumptions behind their application. The starting point is equation (1) in section 4.3, that we take as benchmark specification for our econometric model. The unconditional effect of $eif_{i,t-1}$, not directly available in Table 3, was derived using estimated quantities as follows:

$$\frac{\partial \mathbb{E}(pvt_{i,t})}{\partial eif_{i,t-1}} = \alpha_2 + \alpha_8 \mathbb{E}(educ_{i,t-1}) + \alpha_9 \mathbb{E}(unemp_{i,t-1}) + \sum_{m=1}^{5} \delta_m \mathbb{E}(MACROREG_i^m) \tag{2}$$

where $\mathbb{E}$ is the expectation operator and, for easiness of reading, $MACROREG_i^6$ is taken as the reference macro-region. Macro-region specific effects of $eif_{i,t-1}$ can be further computed by conditioning (2) on the macro-region of interest. These additional quantities are reported in Table H1, which is sought to complement Table 3.

Table H1: Dynamic panel data model estimates. Dependent var.: $\ln$ (private investment$_t$)

| | (1)<br>POLS | (2)<br>FE | (3)<br>DIFF-GMM | (4)<br>SYS-GMM |
|---|---|---|---|---|
| $\ln$ (EIF Inv.$_{t-1}$) : unconditional effect | -0.0002 | -0.0004 | 0.0099 | 0.1128 |
| | (0.031) | (0.029) | (0.098) | (0.076) |
| $\ln$ (EIF Inv.$_{t-1}$) : DACH | 0.0295 | -0.0575 | -0.1204 | 0.2026* |
| | (0.032) | (0.071) | (0.137) | (0.122) |
| $\ln$ (EIF Inv.$_{t-1}$) : NORDICS | 0.0421 | -0.0246 | -0.0805 | 0.0822 |
| | (0.038) | (0.028) | (0.128) | (0.114) |
| $\ln$ (EIF Inv.$_{t-1}$) : FR&BENELUX | 0.0445 | 0.0183 | 0.0475 | 0.1488 |
| | (0.034) | (0.072) | (0.196) | (0.193) |
| $\ln$ (EIF Inv.$_{t-1}$) : SOUTH | -0.0715 | -0.0823 | -0.1757 | -0.1143 |
| | (0.052) | (0.090) | (0.139) | (0.155) |
| $\ln$ (EIF Inv.$_{t-1}$) : BI | 0.0211 | 0.0953 | 0.0436 | 0.2118 |
| | (0.039) | (0.058) | (0.223) | (0.163) |
| $\ln$ (EIF Inv.$_{t-1}$) : CESEE | -0.0991 | 0.0805* | 0.4890 | 0.0775 |
| | (0.103) | (0.049) | (0.420) | (0.339) |
| Obs. | 1,551 | 1,551 | 1,328 | 1,551 |
| F-Test (p-value) | | | 0.019 | 0.000 |
| Hansen (p-value) | | | 0.693 | 0.229 |
| AB AR(2)(p-value) | | | 0.163 | 0.613 |
| Number of Instruments | | | 170 | 184 |
| Year FE | Yes | Yes | Yes | Yes |

* p<0.10, ** p<0.05, *** p<0.01. Standard errors in parentheses. Refer to Table 3 for the full list of coefficients.

### Notes on the different estimators used in the analysis

Equation (1) yields a model in which the explanatory variable $pvt_{i,t}$ is positively correlated with the error term $(\eta_i + \epsilon_{i,t})$ through correlation with $\eta_i$. As such, OLS estimates for the equation (1) in level are inconsistent. Indeed, standard results for omitted variable bias prove that, in this setting, the OLS levels estimator is upward biased (Bond, 2002). Hence, proper panel data estimators are needed, in order to deal with the presence of region-specific fixed effects. Nevertheless, when an autoregressive term is introduced, as Nickell (1981) shows, the Fixed Effects Within Group estimator generally employed in panel data settings is inconsistent as well. The Within Group estimator applies a demeaning transformation to the data, ruling out the fixed effect component $\eta_i$. Notwithstanding, demeaning introduces a negative correlation between the transformed autoregressive term and the transformed error term. When $T$ in the panel is small, as in our case, the downward bias has been shown to be significant. Moreover, intrumenting the autoregressive term with its lags in levels bears a technical fallacy, as these will be still correlated with the demeaned error term.[65]

To address these issues, building on Holtz-Eakin *et al.* (1988) and Arellano and Bond (1991), we apply the Arellano-Bond dynamic panel estimator. This is a general linear estimator suited for settings characterized by 1) "small $T$, large $N$" panels; 2) dynamic left-hand-side variable depending on its own past realizations; 3) independent variables not strictly exogenous, *i.e.* potentially correlated with past and current realizations of the error term; 4) fixed individual effects; 5) heteroskedasticity and autocorrelation *within* individuals, but not *across* them. The Arellano-Bond estimator implies a first-difference transformation of the regression equation (1), which *de facto* sweeps out the fixed effect component. Also, as originally proposed by Anderson and Hsiao (1981), lagged values of the endogenous dependent variable[66] become available as valid instruments, allowing consistent 2SLS estimation. However, to address the inefficiency of the 2SLS estimator in this framework (Roodman, 2006), Arellano-Bond uses a Generalized Method of Moments (Hansen, 1982) approach, known as Difference GMM, in which the model is specified as a system of equations, one per time period, where the instruments applicable to each equation differ.[67]

As argued in Arellano and Bover (1995) and Blundell and Bond (1998), the lagged levels of the endogenous explanatory variables are often rather weak instruments for first-differenced variables, especially if these follow or approach to a random walk. Assuming that first difference of instrumental variables are uncorrelated with the fixed effects, the Blundell-Bond estimator augments Arellano-Bond by using lagged differences as instruments for the variables in levels. The approach (called System GMM) applies GMM estimation not only on the regression equation in first-difference, but on a system of two equations, the original regression equation and the transformed one. This permits the introduction of more instruments and can dramatically improve efficiency (Roodman, 2006).

For this reason, after having estimated equation (1) with Arellano-Bond, we also employ the Blundell-Bond estimator in order to improve the efficiency of our estimates, at the cost of additional assumptions, moment restrictions and, consequently, number of instruments used. We see this also as a robustness check exercise. If there is a clear pattern in the data, robust estimates should not differ too much when using either one of the estimators. However, because of the Blundell-Bond estimator's improvement in efficiency, it is the latter method that we take as reference.

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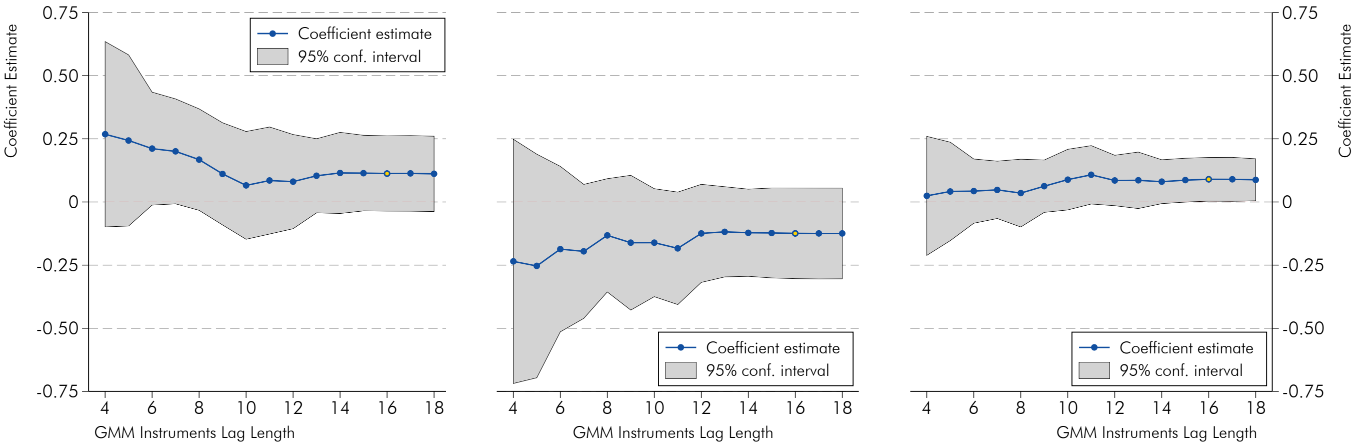
[65] When demeaning equation (1), the $\eta_i$ term cancels out, while the transformed error term will be equal to $\epsilon_{i,t} - \frac{1}{T}(\epsilon_{i,1} + ... + \epsilon_{i,T})$, *i.e.* a function of the original error terms for every year.

[66] If there is no autocorrelation in the idiosyncratic error term, the second and further lags of the dependent variable are available as instruments. Instead, if the error term follows an $AR(1)$ process, one can still follow this strategy by "stepping back" one period and using the third and further lags, and so on and so forth for $AR(n)$ processes.

[67] For instance, in later time periods, additional lagged values of the instruments become available.

# I Robustness checks

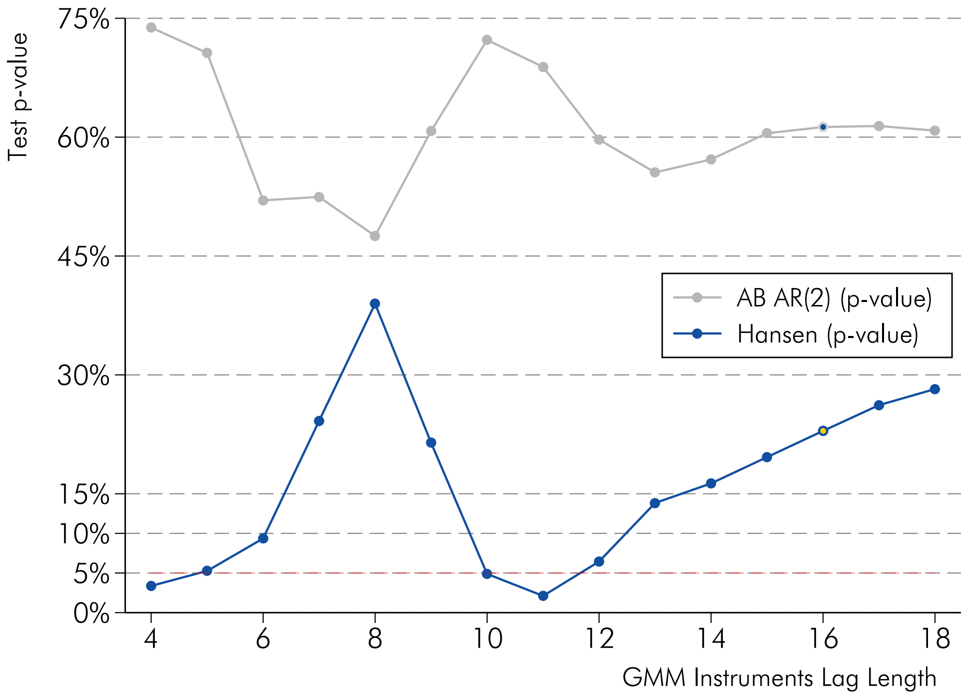
## Figure I1: Parameter stability




(a) $\ln(\text{EIF Inv.}_{t-1})$ (b) $\ln(\text{EIF Inv.}_{t-2})$ (c) $\ln(\text{EIF Inv.}_{t-3})$

**Note:** The dependent variable is $\ln(\text{private investment}_t)$. Figures based on the SYS-GMM estimates.

## Figure I2: Hansen Test and AB Test Stability




**Note:** The Hansen test's null hypothesis is the validity of the overidentifying GMM restrictions (*i.e.* instruments are exogenous). The Arellano-Bond test assumes no second-order autocorrelation in the estimated first-differenced residuals.

## J List of acronyms

- CMU: Capital Market Union
- EDCi: European Digital City index
- ETF: European Technology Facility
- EU: European Union
- EVCA: European Venture Capital Association (formerly, now Invest Europe)
- FE: Fixed-Effects
- GDP: Gross Domestic Product
- GFCF: Gross Fixed Capital Formation
- GMM: Generalised Method of Moments
- ICT: Information and communication technology
- ISCED: International Standard Classification of Education
- LP: Limited Partner
- NPI: National Promotional Institutions
- NUTS: Nomenclature des unités territoriales statistiques
- OECD: Organisation for Economic Co-operation and Development
- OLS: Ordinary Least Squares
- PPI: Producer Price Index
- SME: Small and Medium-sized Enterprise
- SVAR: Structural Vector Auto-Regression
- TEN: Trans-European Network
- VC: Venture Capital

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