The changing patterns of venture capital investments in Europe

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Abstract. In this paper we analyse the changes in the patterns of investments for Venture Capital (VC) investors with different governance structures. We distinguish independent, corporate, bank-affiliated and governmental VC investors. Focusing on a sample of VC investments made in the period 1998-2014 in 28 EU-member countries and Israel, we compute specialization indexes for each investor type along five dimensions (age and industry of target, geographical distance; cross-border and syndicated investments) and compare their evolution across four time periods (booming internet bubble: 1998-2001, bursting post-bubble: 2002-2004, post bubble recovery: 2005-2007, global financial crisis: 2008-2010, and post global financial crisis 2011-2014). We find interesting trends in how investors with different governance structures changed their patterns of investment across time, highlighting the importance of considering the dynamic nature of the VC ecosystem.

Keywords. Venture Capital; Relative specialization index; Europe; Venture Capital firm governance; High-tech start-ups.

1. Introduction

VCs have an important role as prominent equity providers of start-up companies (see the reviews by Da Rin et al. 2013; Drover et al. 2017). One aspect that is attracting a growing interest among academics is the importance of the governance structure of VC investors (Da Rin et al. 2013). The most iconic type of VC is the independent VC (IVC), which has a very specific type of governance: a management company (general partners) manages several pools of capital provided by the limited partners. A crucial element of IVC is that limited partners cannot interfere with the investment selection and management, making general partners independent. Non-independent, or captive, VC investors are relatively more common outside the US (where IVC first developed). They are investment vehicles or business units of a parent company, which – contrary to limited partners in IVC – retains a substantial influence on the management of the fund. The parent company may be a nonfinancial company in the case of a corporate VC (CVC), a financial intermediary in the case of a bank-affiliated VC (BVC), or a governmental body in the case of a governmental VC (GVC). In this work we study how the governance structure of Venture Capital (VC) investors affects their investment patterns in different phases of the economic cycle.

Corporate governance in VC fundamentally influences both the relationships between investors and venture capitalists and between venture-capital firms and the ventures in which they invest (Sahlman 1990). Consistently, the few previous studies that compared the investment portfolios of VC investors with different governance structures highlighted that VC types differ remarkably in their investment patterns (e.g. Bertoni et al. 2015; Dimov and Gedajlovic 2010; Mayer et al. 2005), and play different roles in the VC ecosystem (Bertoni et al. 2018; Ferrary 2010). One of the biggest gaps left by this literature is that it does not study the extent to which changing market conditions affect investment patterns. In fact, previous studies have highlighted that corporate governance influences the organizations' behaviour during periods of crisis (Erkens et al. 2012; Essen et al. 2013). In the context of VC, governance structure may affect the objectives, risk attitude, and investment preferences of different VC investor types in a way that will vary across the economic

cycle. In particular, we study whether the differences highlighted by previous studies in the investment patterns of different VC investor types are *persistent*, in line with the view that they are driven by the different governance of these different investor types or if they tend to vanish over time. In this latter case, one would interpret the differences highlighted by previous studies with reference to the European VC market as a sign of a market imperfection generated by the limited development of this market. In this paper we provide some evidence that, although investment patterns are indeed overall stable, VC types can deviate from their typical investment niche in some phases of the economic cycle.

For this purpose, we focus our empirical analysis on 28 European countries and Israel and study the pattern of investments of IVC, CVC, BVC and GVC investors over a long time period (1998-2014). During this period the changing face of the European VC industry (Bottazzi et al. 2004) substantially evolved in a positive direction. Following the Lisbon European Council in March 2000, policymakers committed to the development of the VC industry, trying to close the gap with the US. Efforts have been made to improve the European VC ecosystem, for instance by homogenizing institutional and regulatory frameworks for VC both nationally and internationally (European Commission 2009), and to increase the amount of financial resources available to financial investors, notably through the creation of the European Investment Fund.[1]

The period we investigate encompasses two major economic crises that severely affected the VC industry: the burst of the internet bubble in the early 2000s and the Global Financial Crisis (GFC) of 2009. Although the origins and geographic and sectorial boundaries of the two crises were different, both events greatly and negatively influenced the VC industry, because of the lack of liquidity in the IPO and M&A markets, the reduction of portfolio company's valuations, and, especially in the case of the GFC, the dearth of funds that hit most private VC investors due to the financial difficulties of insurance companies and large banks. Nonetheless, most work on the effects

[1] Several studies have highlighted the effect of public policy measures to sustain the European VC ecosystem (e.g., Aernoudt 1999; Alperovych et al. 2018; Da Rin et al. 2006).

of the burst of the internet bubble and the GFC on the VC industry is based on U.S. data (Block and Sandner 2009; Gompers and Lerner 2003; Green 2004) and neglects the influence of VC governance on investment patterns.

In this study we use specialization indexes to examine the patterns of investment of different VC types along the following five dimensions: (1) the industry of the investee company, (2) the age at time of the investment, (3) the geographical distance between the investee company and the VC investor, (4) whether the investment is domestic or cross-border, (5) whether the deal is stand-alone, syndicated with the same type of VC investor or syndicated with other VC investor types. We also distinguish five different periods of time: (1) the booming internet bubble period from 1998 to 2001; (2) the bursting post-bubble period from 2002 to 2004; (3) the post-bubble recovery period from 2005 to 2007; (4) the GFC period from 2008 to 2010; and (5) the post-GFC period from 2011 to 2014.[2]

Our approach is similar to the one used by Bertoni et al. (2015), which allows for the comparability of results across studies. However, this work goes beyond Bertoni et al. (2015) in several ways. First, our analysis is based on a larger sample, extracted from VICO 4.0 database, which was developed in the context of the RISIS project, funded by the European Commission under FP7. The VICO 4.0 database contains information on VC investments covering all 28 EU countries (vs 7 countries in Bertoni et al. 2015) and Israel, and a 16-year long period between 1998 and 2014 (vs. the 11 years between 1994 and 2004 in Bertoni et al. 2015). This allows for a more detailed and representative analysis of the patterns of investments of different VC investors and their changes over time. Second, we here use a transformation of the specialization Balassa index used in Bertoni et al. (2015) that improves comparability over time and across categories (Yu et al. 2009). We use these

[2] Macroeconomic conditions during the post-GFC period varies across countries. Northern European countries and Israel experienced a recovery from the crisis, similarly to the U.S. Conversely, in Southern European countries this period was marked by the sovereign debt crisis, peaking in 2011. The few studies that compare the VC industry before and after the global crisis detect several important differences. For example, Block and Sander (2009) formally compare the average investment choices before and after the global crisis in the U.S., finding that in the latter period target companies were older, later stage investments were smaller and done in larger syndicates, while early stage investments were less attractive to CVC. However, because of the different macroeconomic conditions in different countries, whether these results are generalizable is questionable.

indexes also to assess the similarity in the investment patterns of the different types of investors in different periods of time.

The paper proceeds as follows. In section 2, we review prior literature on VC governance. In section 3, we describe the methodology used to examine the investment patterns of the different VC investor types. In section 4, we present the dataset and show some descriptive statistics. Section 5 illustrates the empirical results on the investment patterns of different VC investor types and their evolution in time. Finally, section 6 highlights the contribution of this paper to the VC literature, its policy implications and some possible avenues for future research.

2. Related literature

VC investors differ in ownership and governance configurations, and these differences in turn influence their objectives and investment strategies as well as their investment portfolios, expected returns, and performance of invested companies (Croce et al. 2015; Da Rin et al. 2013). In the work most similar to ours, Bertoni et al. (2015) compare the relative specialization indexes of different VC ownership structures, finding that VC types differ remarkably in their investment patterns and European VC investors' specialization patterns are also significantly different from US ones. Besides this work, to the best of our knowledge, a handful studies have analysed how different VC governance mechanisms relate to their investment patterns. Mayer et al. (2005) compare investment activities of VC investors with their source of financing in Germany, Israel, Japan and the United Kingdom. The authors find that sources of VC funds differ significantly across those countries. Banks are particularly important in Germany, corporations in Israel, insurance companies in Japan, and pension funds in the United Kingdom. Moreover, investments vary among different types of VC funds in terms of stage, sector and geography of investee companies. For instance, BVC investors tend to invest in later stages than CVC investors. Yoshikawa et al. (2004) argue that, in Japan, BVC funds are less prone to engage in active monitoring of their portfolio firms. Instead, compensation and incentive structures employed within the fund lead to larger portfolios that allow to diversify investment risk. Cumming et al. (2008) find similar results, extending the previous work to a wider

range of VC ownership structures. They find that Japanese BVC investors have larger portfolios per manager than individual owner-manager VC investors, leading to lower monitoring of portfolio firms. Croce et al. (2015) study the investment behaviour of BVC investors in the European context. They compare firms financed by BVC investors with a sample of firms financed by IVC investors (and a control group of non VC-backed firms), finding that BVC investors tend to select start-ups with a lower default probability. Dimov and Gedajlovic (2010) investigate the types of investments pursued VC investors in the US, according to how and to whom income and decision rights are allocated under different VC ownership arrangements. Their findings demonstrate different tendencies of VC types with respect to the range and types of investments, with CVC investors having the most focused-early stage, and BVC investors the most diverse-late stage portfolios of companies, while IVC investors show an intermediate level of specialization in both range and types of funded companies. Abrardi et al. (2019) address the switching dynamics between GVC and IVC in a company's investment path, through a theoretical model and an empirical analysis of US VC investors. They find that low economic return firms have a higher probability to be financed by a more-reputable GVC than the incumbent IVC (that exited the investment). Instead, when switching from a GVC to an IVC, these ventures are more likely to be backed by a less-reputable IVC.

Another stream of literature, close to ours, analyses what determines an entrepreneur's choice between VC investors characterized by different governance structures. Andrieu and Groh (2012) investigate how VC types affect deal terms, developing a theoretical model, in which the entrepreneur selects the optimal contract by trading-off the peculiarities of different VC investors, i.e. BVC investors are less effective in supporting investee companies, despite being less financially constrained than independent VC investors. Thus, entrepreneurs should seek capital from either one or the other type of investor based upon the degree of sophistication of their project, any foreseeable need and the relevance of VC support, the liquidation value of the project, and the time to fundraising. Similarly, Hellmann (2002) studies the preference of an entrepreneur between an IVC and a CVC investor. As CVC investors pursue strategic objectives beyond purely financial ones, this can cause

conflicts of interest with the entrepreneur, who should choose the right investor contingent on expected synergies with the CVC or rather prefer a syndicate, where the IVC becomes the lead investor.

Another stream of the literature looking at VC governance focuses on the role and impact of different VC types on the performance of investee companies, such as firm's productivity or sales growth, innovation performance, exit, etc. (e.g., Alperovych et al. 2015; Buzzacchi et al. 2013; Croce et al. 2015).

In conclusion, previous literature on VC ownership and governance has suggested that there are peculiar patterns of VC investment depending on their governance mechanisms. Prior research, however, lacks a comprehensive and up to date empirical evidence concerning the investment patterns of different VC investor types and, especially, the extent to which changing market conditions affect those investment patterns. Moreover, there is a substantial shortage of discussion and evidence regarding the European VC market, as the majority of studies are based in single countries, such as Japan or the US, or on one or two types of VC investors.

3. Methodology

In order to analyse the investment patterns of different types of VC investor, we exploit specialization indexes based on the concept of revealed comparative advantage. The first and most widely used specialization index is the Balassa index, which was originally employed for the comparison of countries' trade flows in order to reveal their comparative advantage from observable trade patterns (Balassa 1965). Specifically, if a country's share of global exports of a specific commodity is greater than that country's overall share of global exports, the country has a revealed comparative advantage in exporting that commodity. Thanks to their versatility and intuitive interpretation, specialization indexes have been used in a number of different research fields in addition to international business, such as scientometric, innovation, and technological studies (e.g., Archibugi and Pianta 1992; Cantwell 1989; Soete and Wyatt 1983).

In this work, we apply specialization indexes to the VC industry, taking inspiration from the

approach used by Bertoni et al. (2015). We use a transformation of the Balassa index, as the original index (Balassa 1965) has some drawbacks. First, it is not scale independent, which means that the distribution of specialization indexes depends on the number of observations across categories (Yeats 1985). Since we have an uneven number of investments made by different VC investor types, this could lead to inconsistent results for categories with fewer observations. Second, the index has an asymmetric and skewed distribution (Dalum et al. 1998). Third, its use in comparative studies over space and time may be problematic, as the sum of all indexes (in our case, for all VC investors) for an individual category is not constant (e.g., Deardorff 1994; Hillman 1980; Hoen and Oosterhaven 2006). We adopt a "normalised" version of the Balassa index (NBI), proposed by Yu et al. (2009), that alleviates the shortcomings illustrated above. The NBI is defined as follows:

$$NBI_{j,k}^{i} = \frac{N_{j,k}^{i}}{\sum_{i=1}^{4}\sum_{k=1}^{M_j} N_{j,k}^{i}} - \frac{\sum_{i=1}^{4} N_{j,k}^{i} * \sum_{k=1}^{M_j} N_{j,k}^{i}}{\sum_{i=1}^{4}\sum_{k=1}^{M_j} N_{j,k}^{i} * \sum_{i=1}^{4}\sum_{k=1}^{M_j} N_{j,k}^{i}} \quad (1)$$

where $N^{i}_{j,k}$ denotes the number of investments by investor i = 1,...4 (i.e., IVC, CVC, BVC, GVC) that belongs to category k = 1,..., Mj of dimension j = 1,...5 (age and industry of target, geographical distance; cross-border and syndicated investments). The NBI index measures the difference between the fraction of investments in category k of dimension j for investor type i (i.e., the first term of equation 1) and its comparative-advantage-neutral level (i.e., second term of equation 1, the number of investments for which its specialization would be zero), in terms of its relative scale with respect to all investments. NBI ranges from -0.25 to +0.25. Positive (negative) values indicate that investor type i's relative specialization in category k of dimension j is higher (lower) than its comparative neutral level (i.e., zero). The greater the NBI score, the stronger is the specialization in category k. For instance, $NBI^{i}_{j,1}$ = 0.01 and $NBI^{i}_{j,2}$ = 0.02 means that the relative strength of investor i's specialization in category 2 is twice of its specialization in category 1. Moreover, the sum of both a category's NBI scores over all investor type and the sum of an investor type's NBI scores over all categories of dimension j are constant and equal to zero (Yu et al. 2009). This is a very important feature because it allows temporal comparison of NBI values. $\Delta_{t,t-1}$ $NBI^{i}_{j,k}>0$ ($\Delta_{t,t-1}$ $NBI^{i}_{j,k}<0$) means

that the growth of investor type i's relative specialization between t-1 and t in category k of dimension j is higher (lower) than the expected growth that is necessary for investor type i to maintain a neutral level of specialization in category k and, therefore, investor type i has increased (decreased) its specialization in that category.

4. Data and descriptive statistics

The sample we use for our analysis is extracted from the VICO 4.0 database. This dataset has been developed in the context of the RISIS project, funded by the European Commission under FP7. VICO 4.0 contains geographical, industry and accounting information on companies that have received at least one VC investment from 1/1/1998 to 31/12/2014, and are located in the 28 countries that are members of the European Union, plus Israel. The information has been collected from different commercial databases (i.e., Thompson One Private Equity, Zephyr, Crunchbase and Orbis). Data consistency across different data sources has been manually cross-checked. The dataset contains information on 24,238 companies and 20,577 VC investors. Companies and investors have been involved in a total number of 68,698 investments (i.e., company-investor-round triads).

VC investors are identified and classified according to the governance of the management company. An investor characterized by an independent management company is classified as an IVC. Investors whose parent companies are non-financial companies are classified as CVC, and those whose parent companies are financial intermediaries are classified as BVC. Finally, if the parent company is a governmental agency or institution, the investor is classified as a GVC. Investments for which the VC investor type is unknown are excluded from the analysis.

Following Bertoni et al. (2015), we only consider the first round in which a given VC investor invests in a given company, excluding all follow-on rounds from the same VC investor. An investor reveals its investment preferences when first investing in a company. Follow-on rounds are instead the result of staging and other contractual practices, and do not necessarily reflect investment preferences. After eliminating the cases that do not meet our selection criteria, we are left with a sample of 46,091 first VC investments made by 15,222 VC investors in 22,854 companies.

Table 1 shows the distribution of VC investments according to the VC investor type, the five periods of analysis, the country of the investee company and the five dimensions considered.

[Insert Table 1 around here]

The majority of investments are made by IVC investors (75.4%). GVC investments are the second investor type for number of investments (10.2%), which is consistent with the importance of GVC in Europe when compared, for instance, to the US. CVC represents 7.9% of the investments, followed by BVC (6.6%). The distribution of investments across industries highlights the interest of European VC in the software (28%), biotechnology and pharmaceuticals (11.4 %) and R&D and engineering (11.1%) industries. Companies operating in financial, real estate and consultancy services (10.3%), internet and telecommunication (TLC) services (8.2%) and business support services (6.0%) are also important targets of VC investments. Investee companies are typically young at the time of the investment: 47.4% of the investments are in newly funded companies (less than two years-old), while only 24% of the investments are made in companies older than 5 years. Regarding location of investee companies, in 22.7% of investments, the VC investor is located less than 10 km away from the investee company, and in 42.5% of investments, the distance is less than 100 km. The distance is more than 500 km for only 28.7% of investments. The vast majority of the investments in our sample are domestic (70.5%). These data highlight the local bias of VC investors Finally, syndicated investments represent 64.3% of the sample. 30.9% of the sample is composed of syndicates between different types of VC investors.

For each of the dimension analysed above, the distributions of VC investments across the different categories have changed during the time frame analysed and are shown in Table 2: the χ^2 distribution tests across periods and along all the dimensions considered are significant at the 1% level. Some distinguishable trends emerge. VC investors had the highest propensity to invest at foundation or in 1-2 years old companies during the internet bubble. The propensity to invest in companies located closer than 10 km increased in time, but there was also a higher propensity to

invest in distant and foreign companies during economic growing periods (i.e., bubble and after GFC crisis) than during the crises periods. Stand-alone investments were much more frequent during the crises while syndication among same type investors became gradually more frequent after the burst of the internet bubble.

[Insert Table 2 around here]

5. Results

5.1 Investment patterns of different VC investor types in Europe

The results on NBI specialization indexes are illustrated in Table 3. Because NBI values are small, we scale them by a factor of 100 to improve readability. Overall, in accordance with Bertoni et al. (2015), the results show that each VC investor type has a defined pattern of investment specialization with respect to the dimensions considered. Moreover, the patterns of specialization of the different types of VC investor are largely similar to those highlighted by Bertoni et al. (2015).

[Insert Table 3 around here]

IVC investors, compared with other VC investor types, are more specialized in the internet & TLC services, software and business support services, while they are less inclined to invest in R&D engineering, high-tech manufacturing and financial, consultancy and real estate sectors. As to the age of invested companies, IVC investors are less inclined to invest at foundation with respect to other investors, while they exhibit large positive NBI indexes for companies located at more than 500 km from their headquarters and to a less extent for companies less than 10 km far away. They are also specialized in cross-border deals, in comparison with the other investor types. Finally, IVC investors have a strong tendency to syndicate with other IVC investors.

The NBI of CVC investors regarding target industries are quite small in absolute terms. Still, they show a preference for software and a reluctance to invest in R&D engineering and other manufacturing. Regarding the other dimensions, CVC investors tend to avoid older (> 5 years old) companies, and are specialized in distant (more than 500 km) and cross-border investments. Finally,

they show a marked tendency to syndicate with other VC investor types (mostly with IVC).

BVC are specialized, as expected, in financial, consultancy and real estate investments, while they tend to avoid software firms. They specialize in less risky investments: mature (more than 5 years-old) companies and domestic investments. They also tend to syndicate with other types of VC investors.

The investment pattern of GVC investors deviates markedly from those of the other investor types, in line with Bertoni et al (2015). In terms of industry specialization, GVC investors focus on R&D and engineering services, biotech and pharmaceuticals, and other high-tech manufacturing industries, while disregarding internet and TLC services, software and business support services. They have a clear inclination to invest in the youngest companies (<1 year) and avoid mature companies (> 5 years old). These patterns could be easily explained by the role GVC investors have played in compensating the lack of equity capital in particular sectors or investment stages due to the investment patterns of other VC types. GVC investors are also strongly oriented towards domestic targets. They seem to avoid more distant investments (> 500 km from their premises) in comparison to other types of VC investors. GVC investors have also the strongest propensity to invest on a stand-alone basis. Conversely, when they form syndicates, they participate in mixed ones.

In Table 4 we show the values of the Spearman's correlation index computed over all five dimensions for all pairs of VC investor types. A higher correlation indicates that the patterns of investments are more similar. We find that, overall, IVC investment patterns are different from those of GVC (similarly to Bertoni et al. 2015) and BVC investors. We also detect a positive, even if less strong, correlation (significant at 5% level) between GVC and BVC investors, opposite to Bertoni et al (2015). This is attributable mainly to their preference for domestic companies, their similar syndication strategies (they both privilege mixed syndicates) and the similar investment choices in some industry categories (e.g., both types avoid internet and software firms). Finally, GVC investment patterns differ significantly (only at 10% level) from those of CVC investors.

[Insert Table 4 around here]

5.2 Evolution of investment patterns of different VC investor types over time

To check whether the investment pattern of different VC investor type varied over time, we computed NBI indexes separately using the subsamples of investments taking place in the five periods presented above (namely, the booming internet bubble period, the bursting post-bubble period, the post-bubble recovery period, the GFC period, and the post-GFC period). We do not report all the NBIs to save space, but figures 1 to 4 show the results graphically.

[Insert Figures 1 to 4 around here]

Figure 1 shows that the patterns of investment of IVC investors over time. In terms of industry, during the bubble burst, the specialization in financial, consultancy and real estate was particularly low and the one in R&D engineering especially high. In the post-bubble recovery and GFP periods, IVC investors shifted preference from companies at foundation to 1-2 years old companies, while the preference for older companies remained similar over time. The distance from their investee companies progressively increased (>500 km category at the expense of 100-500 km one) since the booming internet bubble, as did IVC investors' specialization for cross-border investments. Syndication patterns were instead quite stable.

Figure 2 shows CVC investors' specialization over time. The industry patters were quite stable, with the exception of a marked preference for ICT manufacturing during the post-bubble burst and for companies at foundation in the GFC. In time, CVC became more specialized in distant and cross-border investments, while they were less and less interested in syndicating with other CVC partners.

Figure 3 reports BVC specialization patterns, which appear quite stable over time. Still, it seems that some of the peculiar traits of the investment pattern of BVC investors somehow faded over time, as there was a progressive decrease in the specialization in financial, consultancy and real estate industries, in mixed syndicated investments and in investments at very high distance.

Finally, in figure 4 we can see how GVC investment patterns vary over time. Their specialization in biotechnology & pharmaceuticals and ICT manufacturing peaked during the post-GFC period, while

the one in R&D engineering peaked during the GFC. GVC became progressively more specialized in 1-2 years old companies and less specialized in newly born companies (except during the GFC). GVC also shifted away from companies located further than 500 km, but towards companies located between 100 and 500 km. Still, their specialization in domestic companies remained became stronger over time. Lastly, in time GVC tend to syndicated more and more with other types of VC.

In Table 5, for each investor type, we show the values of the Spearman's correlation index computed between the NBIs in different periods. The investment patterns of each investor type proves to be quite stable over time, as highlighted by the positive and significant (and quite large) values of the correlation indexes across almost all time periods. The only exceptions are represented by IVC and BVC's indexes related to the booming internet bubble period, which are not correlated with any other subsequent period. We do not find a lack of correlation for CVC investors among the different periods, although these investors are considered to be the less persistent type of investor in the literature (Bertoni et al. 2015). Nevertheless, after the bubble the investment patterns of all types of VC investors have been strongly *persistent*, suggesting that there are significant structural difference in the governance of these four types of VC investors linked to their investment behaviour and that do not fade over time.

[Insert Table 5 around here]

To further test whether the similarity or dissimilarity between the patterns of investment of different VC types evolved in time, we computed the Spearman's correlation between the values of the NBI indexes of different pairs of VC investor types in each of the five periods under examination, and show them in Table 6.

[Insert Table 6 around here]

The patterns were mostly stable over time, as shown by the persistent negative correlations of the NBIs of IVC with BVC, IVC with GVC and CVC with GVC (although with different levels of significance). Few changes in correlation patterns emerge after the internet bubble period. First, the

NBIs of IVC and CVC investors were negatively correlated during the internet bubble, but such correlation disappeared in later periods. The correlation between the NBIs of BVC and CVC investors was positive during the internet bubble, decreased in time and became significantly negative after the GFC. BVC and GVC had a negative correlation during the bubble, which turned to positive in later periods. All in all, these results indicate that the internet bubble period was quite peculiar in terms of relationships between the investment patterns of different types of VC. After that period, such relationships remained instead persistent over time.

6. Discussion and Conclusions

In this paper we studied the evolution over time of the patterns of investment of different types of VC investors: IVC, CVC, BVC and GVC. We used a transformation of the original Balassa specialization index, to compare specialization indexes over time. A first interesting result of our study is that, in line with previous studies (Bertoni et al. 2015; Dimov and Gedajlovic 2010; Mayer et al. 2005), we find that different types of VC investors diverge remarkably in their investment patterns, coherently with their different role played in the market. An analysis of the correlation between the specialization indexes, confirm that each VC type has its own distinctive pattern of investment, and the only similarity seems to be present between BVC investors and GVC investors.

Coherently with the documented risk aversion (Bertoni et al. 2015), European IVC investors avoid investing at foundation, they prefer companies belonging to specific industry segments (e.g., internet & TLC and software) and engage in both local (Cumming and Dai 2010) and international investments, often syndicated with other IVC investors. CVC investors have similar preferences, but their industry specialization is less defined, they do not have an inclination to invest nearby, they avoid older companies and almost never syndicate with other CVC investors. These patterns are coherent with CVC investors' aim at creating long-term value to their parent companies by benefiting from technological synergies with the portfolio ventures (Hellmann 2002). The primary objective of BVC investors is to support the establishment of profitable bank relationships with investee companies (Hellmann et al. 2008; Mayer et al. 2005). In fact, they select mature and local companies,

often in financial, consultancy and real estate sectors, and they often syndicate with other investor types. Lastly, GVC investors were often established to fill the funding gap left by private investors and to fulfil regional development objectives (Colombo et al. 2016). They specialise in industrial sectors generally avoided by private VC investors (e.g., R&D and engineering services, biotechnology and pharmaceuticals, high-tech manufacturing) and favour local and domestic investment in start-ups.

A second interesting result of our study is that the investment patterns of different VC types proved to be relatively persistent over time, and that – on average – investors tend to maintain their niches throughout the ups and down of the VC market. The patterns of VC types have become more distinct in time, with a higher tendency to invest at distance among IVC and CVC investors and an increasing preference for local and syndicated deals for GVC. Interestingly, the patterns of BVC investors have become less marked over time in terms of industry, geography and syndication preferences. Investment patterns depend on differences in the strategic objectives, time horizon and capabilities across different investor types. The stability of investment patterns, thus, indicates that these underlying characteristics of VC investors have not changed substantially over the time period we looked at.

An exception to the stability of investment patterns is the booming period before the burst of the internet bubble. During this period, investors that generally exhibit similar investment patterns (like IVC and CVC), where instead insisting in different niches of the market, and investors that are generally distinct (like IVC and GVC) where, instead, more closely correlated. There are two things that make that period unique in the history of VC. First, it was a very early period in the European VC ecosystem, and it is actually possible that investment patterns for the different types of investors were not yet completely settled. Second, it was an exceptional period in terms of start-up valuations and exit (with the creation of so-called new markets and unprecedented levels of underpricing for internet stocks), which might have perturbed the natural equilibrium of VC investors.

Our study is admittedly exploratory in nature, but we believe that it opens the way to a more

theoretically funded analysis of investment patterns. First, whereas the investment patterns are overall stable, we do observe some fluctuations around this long term equilibrium and it would be interesting to understand the extent to which the changing boundary conditions (e.g., in terms of economic and exit conditions, but also in terms of taxation and regulation) determine these fluctuations. Another interesting area of research would be the analysis of how GVC has evolved as a result of changing policies. European policymakers have experienced different models of GVC (e.g., in terms of regional focus, governance and investment objectives), and exactly how these models have affected the evolution of the investment specialization of GVC is still unexplored. BVC is another VC type that needs some closer scrutiny. BVC is the investor type that has received in general the least attention from the literature. Our analysis suggests that some of the investment preferences of BVC investors have recently become less evident, and it would be interesting to know to what extent this is linked with the significant shocks experienced by banks during the GFC.

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Tables

Table 1. Distribution of VC investments

	N	*%*		*N*	*%*
Investor type			*Period*		
Independent VC (IVC)	34,732	75.4	Booming internet bubble (1998-2001)	11,310	24.54
Corporate VC (CVC)	3,624	7.9	Bursting post-bubble (2002-2004)	6,742	14.63
Bank-affiliated VC (BVC)	3,059	6.6	Post-bubble recovery (2005-2007)	7,335	15.91
Governmental VC (GVC)	4,676	10.2	GFC (2008-2010)	7,138	15.49
Total	46,091	100.0	Post-GFC (2011-2014)	13,566	29.43
Industry of the investee company[a]			Total	46,091	100.0
Biotech & Pharma	3,711	11.4	*Country of the investee company*		
ICT manufacturing	1,707	5.2	United Kingdom	11,971	26.0
High-tech manufacturing	1,449	4.4	France	8,226	17.9
Internet & TLC	2,675	8.2	Germany	6,546	14.2
Software	9,147	28.0	Israel	3,299	7.2
R&D Engineering	3,617	11.1	Spain	2,367	5.1
Wholesale & retail	1,347	4.1	Sweden	2,258	4.9
Financial, Consultancy & Real Estate	3,358	10.3	Finland	1,890	4.1
Business support services	1,954	6.0	Netherlands	1,605	3.5
Other manufacturing	2,153	6.6	Ireland	1,274	2.8
Other services	1,507	4.6	Belgium	1,113	2.4
Total	32,625	100.0	Italy	1,112	2.4
Age of the investee company at the time of investment			Denmark	1,094	2.4
<1years	4,944	14.46	Austria	568	1.2
1-2years	11,266	32.94	Poland	508	1.1
3-5years	9,795	28.64	Portugal	498	1.1
>5years	8,194	23.96	Bulgaria	367	0.8
Total	34,199	100.0	Hungary	352	0.8
Distance between VC investor and investee company			Czech Republic	136	0.3
<10km	7,750	22.7	Estonia	135	0.3
10-100km	6,732	19.7	Latvia	117	0.3
100-500km	9,847	28.9	Lithuania	110	0.2
>500km	9,771	28.7	Romania	106	0.2
Total	34,100	100.0	Greece	101	0.2
Location of the investee company with respect to the investor			Luxembourg	100	0.2
Same country	25,669	70.5	Cyprus	74	0.2
Different country	10,740	29.5	Slovakia	64	0.1
Total	36,409	100.0	Croatia	63	0.1
Syndicated VC deals			Slovenia	28	0.1
Stand-alone	16,440	35.7	Malta	9	0.0
Syndicated-same type	15,386	33.4	Total	46,091	100.0
Syndicated-mixed	14,265	30.9			
Total	46,091	100.0			

[a] ICT manufacturing includes components, computers, telecommunication equipment. High-tech manufacturing includes robotics and automation equipment, energy, aerospace. Other manufacturing includes all other low-tech manufacturing industries. Other services include accommodation, media & publishing, public & social activities, sport, transportation services.

Table 2. Distribution of VC investments in different investment periods

	Booming internet bubble 1998-2001		Bursting post-bubble 2002-2004		Post-bubble recovery 2005-2007		GFC 2008-2010		Post-GFC 2011-2014	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Industry of the investee company[a]										
Biotech & Pharma	598	8.8	642	13.9	765	14.1	719	12.7	987	9.8
ICT manufacturing	387	5.7	382	8.3	338	6.2	318	5.6	282	2.8
High-tech manufacturing	238	3.5	181	3.9	327	6.0	322	5.7	381	3.8
Internet & TLC	600	8.8	195	4.2	328	6.0	435	7.9	1,117	11.0
Software	2,134	31.4	1,091	23.6	1,198	22.0	1,362	24.1	3,362	33.3
R&D Engineering	574	8.5	592	12.8	707	13.0	821	14.5	923	9.1
Wholesale & retail	271	4.0	173	3.7	188	3.5	216	3.8	499	4.9
Financial, Consultancy & Real Estate	796	11.7	540	11.7	553	10.2	524	9.3	945	9.4
Support services	481	7.1	275	5.9	297	5.5	323	5.7	578	5.7
Other manufacturing	387	5.7	354	7.6	467	8.6	377	6.7	568	5.6
Other services	328	4.8	207	4.5	274	5.0	244	4.3	454	4.5
Total	6,794	100.0	4,632	100.0	5,442	100.00	5,661	100.0	10,096	100.0
					Pearson chi2(40) = 1.2e+03 Pr = 0.000					
Age of the investee company at the time of investment										
<1year	1,892	23.5	511	10.5	727	13.0	764	12.7	1,050	10.9
1-2years	3,217	39.9	1,324	27.2	1,445	25.8	1,784	29.7	3,496	36.2
3-5years	1,761	21.8	1,941	39.9	1,614	28.8	1,693	28.2	2,786	28.9
>5years	1,198	14.9	1,090	22.4	1,816	32.4	1,771	29.5	2,319	24.0
Total	8,068	100.0	4,866	100.0	5,602	100.0	6,012	100.0	9,651	100.0
					Pearson chi2(12) = 1.8e+03 Pr = 0.000					
Distance between VC investor and investee company										
<10km	1,684	20.3	1,170	21.5	1,228	21.3	1,259	23.2	2,409	26.3
10-100km	1,636	19.7	1,197	22.0	1,194	20.7	1,179	21.8	1,526	16.6
100-500km	2,310	27.8	1,670	30.7	1,795	31.2	1,682	31.0	2,390	26.0
>500km	2,674	32.2	1,403	25.8	1,540	26.8	1,301	24.0	2,853	31.1
Total	8,304	100.0	5,440	100.0	5,757	100.0	5,421	100.0	9,178	100.0
					Pearson chi2(12) = 327.75 Pr = 0.000					
Location of the investee company										
Same country as the investor	6,028	64.5	4,282	74.5	4,326	71.9	4,256	75.6	6,777	70.1
Different country from the investor	3,325	35.6	1,466	25.5	1,687	28.1	1,372	24.4	2,890	29.9
Total	9,353	100.0	5,748	100.0	6,013	100.0	5,628	100.0	9,667	100.0
					Pearson chi2(4) = 286.49 Pr = 0.000					
Syndicated VC deals										
Stand-alone	3,674	32.5	2,952	43.8	3,113	42.4	2,489	34.9	4,212	31.1
Syndicated-same type	3,660	32.4	1,715	25.4	2,196	29.9	2,409	33.8	5,406	39.9
Syndicated-mixed	3,976	35.2	2,075	30.8	2,026	27.6	2,240	31.3	3,948	29.1
Total	11,310	100.0	6,742	100.0	7,335	100.0	7,138	100.0	13,566	100.0
					Pearson chi2(8) = 767.11 Pr = 0.000					

[a] ICT manufacturing includes components, computers, telecommunication equipment. High-tech manufacturing includes robotics and automation equipment, energy, aerospace. Other manufacturing includes all other low-tech manufacturing. Other services include accommodation, media & publishing, public & social activities, sport, transportation service.

Table 3. Normalised Balassa Indexes (NBI) by VC investor type

	IVC	*CVC*	*BVC*	*GVC*
Industry of the investee company[a]				
Biotech & Pharma	-0.083	-0.007	-0.050	0.140
ICT manufacturing	-0.122	0.057	-0.009	0.073
High-tech manufacturing	-0.250	-0.045	0.078	0.217
Internet & TLC	0.358	0.087	-0.070	-0.375
Software	0.406	0.257	-0.339	-0.325
R&D Engineering	-0.346	-0.132	-0.102	0.581
Wholesale & retail	0.011	-0.049	0.076	-0.039
Financial, Consultancy & Real Estate	-0.242	-0.011	0.359	-0.106
Business support services	0.274	0.012	-0.062	-0.224
Other manufacturing	-0.117	-0.144	0.126	0.136
Other services	0.109	-0.025	-0.007	-0.078
Age of the investee company at the time of investment				
<1year	-0.127	0.080	-0.180	0.228
1-2years	0.074	0.182	-0.308	0.052
3-5years	-0.002	0.053	-0.031	-0.020
>5years	0.055	-0.314	0.519	-0.260
Distance between VC investor and investee company				
<10km	0.178	-0.581	-0.066	0.468
10-100km	-0.433	-0.413	-0.015	0.861
100-500km	-1.001	-0.521	0.177	1.345
>500km	1.255	1.515	-0.096	-2.675
Location of the investee company				
Same country as the investor	-1.764	-1.512	0.258	3.019
Different country from the investor	1.764	1.512	-0.258	-3.019
Syndicated VC deals				
Stand-alone	-0.591	-0.507	0.126	0.972
Syndicated-same type	7.179	-2.208	-2.031	-2.940
Syndicated-mixed	-6.588	2.715	1.905	1.967

For each investment dimension, table shows the NBI of each investor in each investment category. NBI indexes multiplied by a factor of 100.

[a] ICT manufacturing includes components, computers, telecommunication equipment. High-tech manufacturing includes robotics and automation equipment, energy, aerospace. Other manufacturing includes all other low-tech manufacturing industries. Other services include accommodation, media & publishing, public & social activities, sport, transportation services.

Table 4. Spearman's correlation of the NBIs of different VC investor type

	IVC	*CVC*	*BVC*
CVC	0.292	1	
BVC	-0.680***	-0.305	1
GVC	-0.891***	-0.381*	0.478**

Number of observations: 24. * p<10%, ** p<5%, *** p<1%.

Table 5. Spearman's correlation of the NBIs of the same VC investor type in different time periods

	Booming internet bubble	*Bursting post-bubble*	*Post-bubble recovery*	*GFC*
IVC				
Bursting post-bubble	0.010	1		
Post-bubble recovery	-0.094	0.702***	1	
GFC	-0.161	0.610***	0.941***	1
Post-GFC	-0.123	0.714***	0.823***	0.855***
CVC				
Bursting post-bubble	0.780***	1		
Post-bubble recovery	0.665***	0.832***	1	
GFC	0.837***	0.791***	0.797***	1
Post-GFC	0.814***	0.791***	0.697***	0.773***
BVC				
Bursting post-bubble	0.336	1		
Post-bubble recovery	-0.006	0.677***	1	
GFC	0.126	0.731***	0.879***	1
Post-GFC	0.008	0.716***	0.789***	0.868***
GVC				
Bursting post-bubble	0.853***	1		
Post-bubble recovery	0.768***	0.712***	1	
GFC	0.797***	0.722***	0.954***	1
Post-GFC	0.842***	0.768***	0.894***	0.913***

Number of observations: 24. *** p<1%.

Table 6. Spearman's correlation of the NBIs of different VC investor types in the five time periods

	IVC	*CVC*	*BVC*
Booming internet bubble			
CVC	-0.753***	1	
BVC	-0.549***	0.601***	1
GVC	0.031	-0.396*	-0.358*
Bursting post-bubble			
CVC	0.191	1	
BVC	-0.617***	-0.171	1
GVC	-0.843***	-0.410**	0.412**
Post-bubble recovery			
CVC	0.173	1	
BVC	-0.703***	-0.263	1
GVC	-0.790***	-0.256	0.320
GFC			
CVC	0.141	1	
BVC	-0.588***	-0.217	1
GVC	-0.868***	-0.215	0.334
Post-GFC			
CVC	0.067	1	
BVC	-0.752***	-0.345*	1
GVC	-0.884***	-0.216	0.682***

Number of observations: 24. * p<1%.

Figure 1. Normalised Balassa Indexes (NBI) – IVC

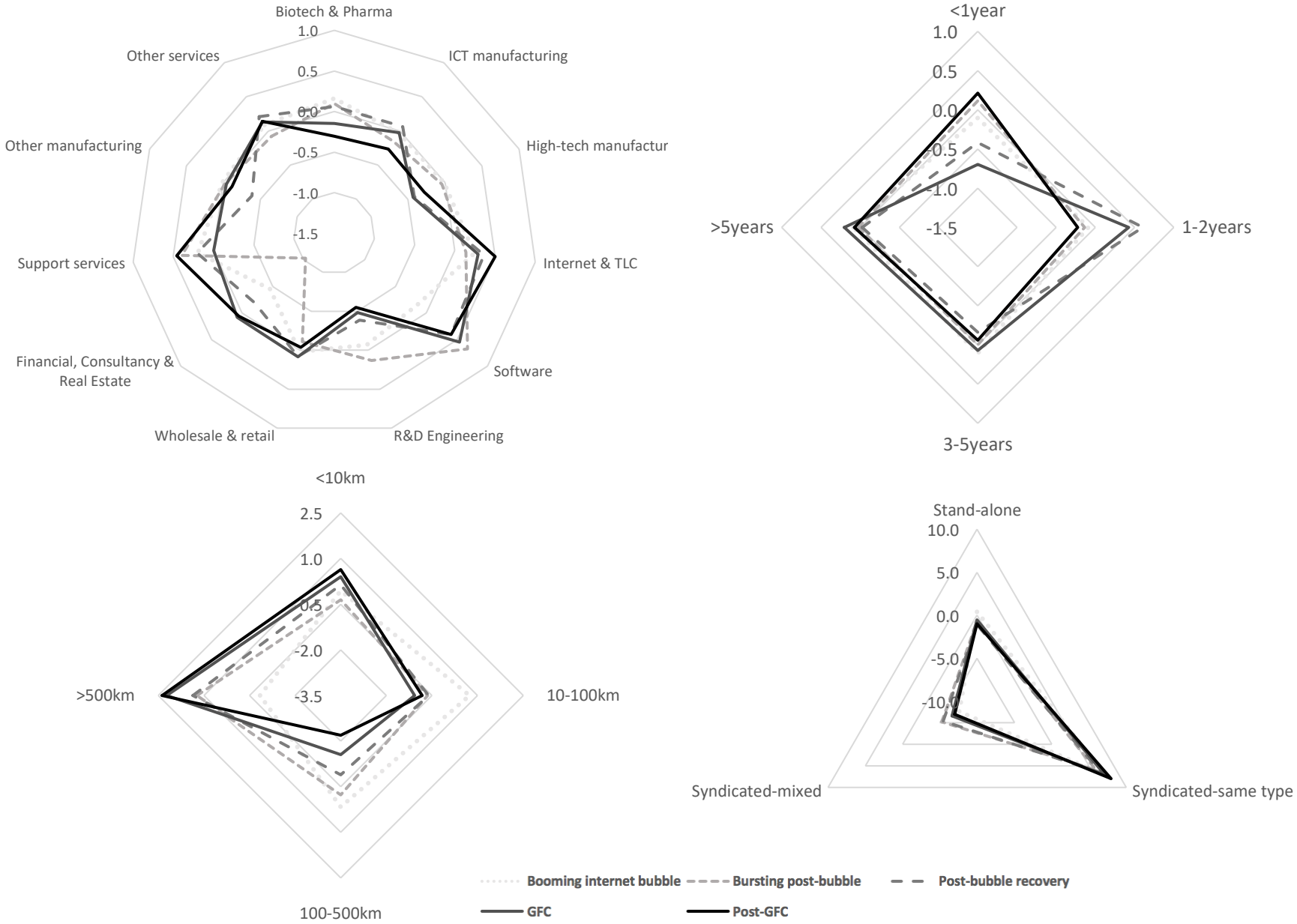

Figure 2. Normalised Balassa Indexes (NBI) – CVC

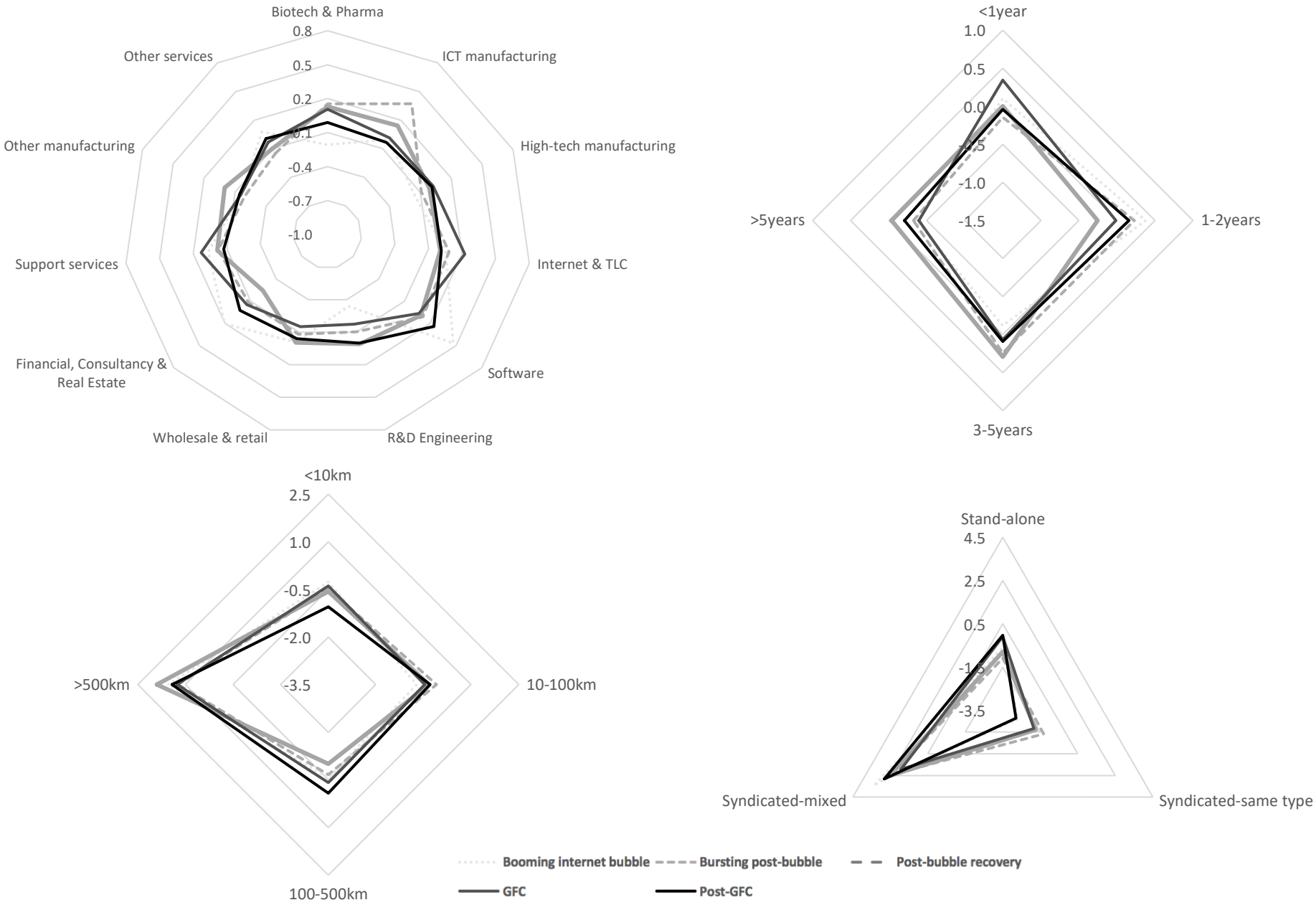

Figure 3. Normalised Balassa Indexes (NBI) – BVC

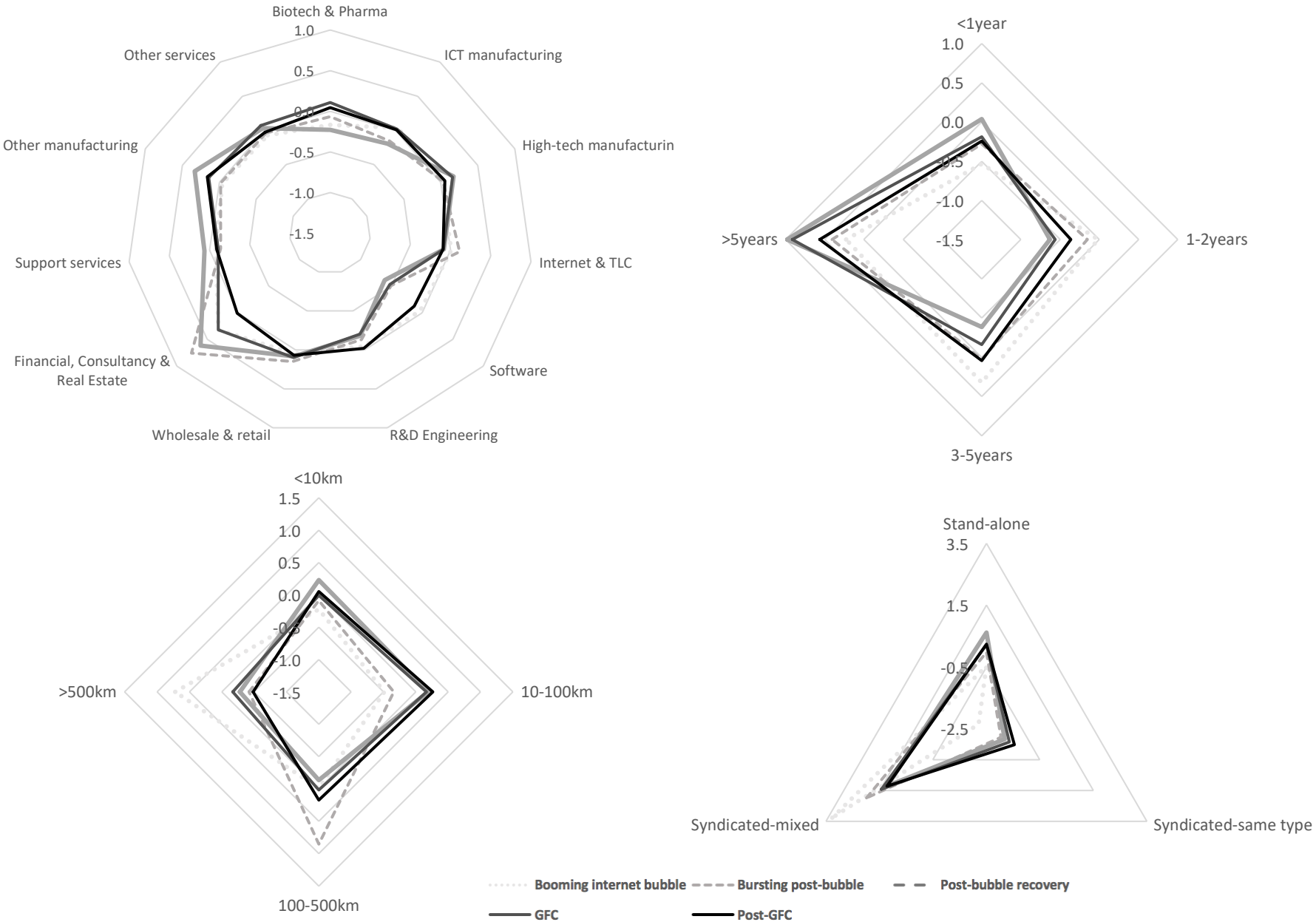

Figure 4. Normalised Balassa Indexes (NBI) – GVC