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The impact of concentration among venture capitalists: revisiting the determinants of venture capital

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ABSTRACT

This article analyzes the impact of the level of concentration among Venture Capitalists (VCs) on the supply of venture capital (VC), through the reduced form model for the equilibrium amount of VC (using a simultaneous equation model on aggregated data from 15 European countries). It is shown that the level of concentration among VCs has a positive effect on VC supply, so creating conditions to increase the level of concentration can stimulate VC supply. The findings reveal the importance of unemployment and personal income rate on VC demand and the positive impact of stock market capitalization on VC supply.

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Venture capital determinants; Europe; Herfindahl – Hirschman index; improvement-driven opportunity entrepreneurial activity; simultaneous equation model

1 Introduction

Venture Capital (VC) is a major driver of economic development, innovation and employment. This fact has been recognized both through research on VC and through international institutions. According to Invest Europe (2022), in 2022, total equity (including Venture Capital, Buyout and Growth) invested in European companies has supported more than 8,895 companies, for an overall amount of €138 billion, including innovative start-ups in growth, medium-sized companies wishing to develop themselves, large companies, and companies with revitalization needs.

New ventures (especially high-tech companies), in their early stages and with high levels of risk, present: information asymmetries associated with the highly technical content of their investment projects; low value and an intangible nature of most of their assets (which cannot serve as collateral); and the lack of history, which ultimately discourages traditional investors such as banks from lending capital to these companies (Berger and Udell 1990; Carpenter and Petersen 2002; Denis 2004; Chen et al. 2010; Colombo, D'Adda, and Quas 2018). Both Hyytinen and Toivanen (2003) and Chen et al. (2010) state that small and entrepreneurial technological companies are more likely to have higher levels of information asymmetry. They will always be companies with highly uncertain future prospects, and therefore, potentially serious agency conflicts (Chen et al. 2010).

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VC represents an attractive source of external equity capital for entrepreneurial ventures, specifically high-tech ones (Gompers and Lerner 2001; Hyytinen and Toivanen 2003). Indeed, Venture Capitalists (VCs) provide not only long-term equity finance but also business skills to high growth-potential companies. They possess superior screening capabilities and use monitoring and staging mechanisms to address information asymmetries more effectively than traditional financial intermediaries (Kaplan and Strömberg 2001; Chen et al. 2010; Colombo, D'Adda, and Quas 2018).

As VCs accept relatively high levels of risk and uncertainty when investing in new ventures, they resort to various investment practices in the hope of high return (Park LiPuma and Park, 2019). Although the financial capital provided by the different types of investors is fungible, they differ in the ways in which risk is mitigated and may require different contractual conditions as well as different forms of organization in the market (Park and Steensma 2012).

The recognition of VCs' importance as intermediaries in financial markets justifies the interest in knowing their determinants. On the demand side, VC is a financing alternative for entrepreneurs with innovative projects with high growth potential and high levels of uncertainty. On the supply side, banks, pension funds, insurance companies, academic institutions, funds of funds, corporate investors, government agencies and private investors provide risk capital hoping to earn higher returns.

The importance of this issue justifies the existence of several studies about the determinants of VC. More research on this topic is necessary for four main reasons. First, conclusions differ regarding the impact of some determinants on the VC market. For instance, Gompers and Lerner (1998a) conclude that GDP has a significant and positive impact on VC whereas in Jeng and Wells (2000) GDP is not statistically significant. Second, the data used in prior research have limitations. For example, in some European countries the VC market took the first steps just before the nineties, so the time series used in previous research cover only the initial phase of these markets' development. Third, most studies are unable to distinguish the main determinants of demand and supply as they use regression analysis to estimate the reduced form equilibrium of VC activity. Lastly, and the main motivation for our study, the structure of the VC market was considered in some work, but studying the type of contracts to mitigate the level of information asymmetry, the effects of VCs' location and, more recently, the success of VC investments in startups. Thus, the motivation for the present work is maintained.

The effect of market structure has been analyzed in the VC literature, but considering effects on "VC geography" and investor relations when syndication occurs in the rounds of VC investments. For instance, Colombo, D'Adda, and Quas (2018), Chen et al. (2010), Christensen (2007) and Mason and Harrison (2002) studied the geographical specialization of VC. Park, LiPuma, and Park (2019) studied the relationship between investment of corporate VC (CVC) and foreign VC (FVC), and the concentration of investors involved in a financing round. Sorenson and Stuart (2001) studied how interfirm networks in the U.S. VC market affect spatial patterns of exchange. These last two studies focused more on the effect of VC concentration in the case of syndication. Hong, Serfes, and Thiele (2020) studied the effect of a competitive supply of VC on startup success exits.

This work aims to contribute to the literature on the equilibrium of VC markets by analyzing the impact of the level of VC concentration.

In fact, the way the VC market is structured is important when looking at the determinants of demand and supply.

From the point of view of venture capital supply, lower levels of concentration increase the supply. Concentration levels, and also competition, between VCs also influence the added value that this type of intermediary gives to their portfolio companies. With lower levels of competition, VCs perform more intensive screening, allowing a reduction in the level of uncertainty and asymmetries of information. Li and Mahoney (2011) argue that competition can drive down the value of growth options, concluding that competition reduces the negative impact of uncertainty on investment (Guiso and Parigi 1999; Bulan 2005; Li and Mahoney 2011). A more competitive supply of VC forces investors to provide funding in exchange for less equity, and also to conduct higher valuations of all startup companies regardless of whether they have high or low-quality projects (Hong, Serfes, and Thiele 2020).

An example of the impact of the VC market structure on the supply of this type of financing is what happened in the 1990s. These were the years of the "internet explosion" and of Internet-related companies characterized by low investment values, high levels of risk and uncertainty, but with high potential for growth and income creation (as shown by the high values associated with IPOs at that time). As Hellmann and Puri (2002) and Christensen (2007) pointed out, in these years the structure of the competition between venture capitalists changed dramatically in two ways: with a massive entry of new entrants and changes in more experienced venture capitalists. As Christensen (2007) argued, competition, and the need to build up competencies, can result in more concentration. Higher funds in the market for investments in VC were observed (therefore an increase in the supply of this type of funds).

Changes in the structure of the VC market lead VCs to specialize in the type of investments they make. According to Christensen (2007), two theories support these VCs' needs for specialization: competence-based theory and traditional financial theory. Competence-based theory argues that increased competition in the industry will result in greater specialization, while traditional financial theory argues that the appropriate answer is diversification in order to spread risk.

The main goal of this study is to introduce the degree of concentration among VCs as a potential determinant of the VC supply.

This study will use European data for the period between 1992 and 2009 (18 years) and with a Simultaneous Equation Model (allowing the distinction between the determinants of the VC demand and the VC supply). The Oster methodology (Oster 2019) is used to study the occurrence of possible omitted variable bias.

The results show that lower concentration levels among VCs lead to a greater supply of VC resources. Thus, a contribution is made to the entrepreneurial financial literature, showing that the level of VC concentration is a determinant of VC supply.

Using simultaneous equation models, it also helps clarify the impact of some determinants (e.g., GDP) on VC activity.

The remainder of this paper is organized as follows: in Section 2 we discuss, at a theoretical level, the external determinants of VC and introduce concentration among VCs, also presenting the control variables in order to allow for model validation. Section 3 describes our data set and the methodology used. Section 4 checks the robustness of the

results. In Section 5 we present the results and Section 6 discusses and summarizes the main findings of our work.

2 Literature review and theory

2.1 External determinants of venture capital

Previous work (see Hellmann 1998; Rin, Nicodano, and Sembenelli 2006; Armour and Cumming 2006) has reported the difficulty in convincingly identifying variables which affect only the demand or only the supply of VC, which implies that estimation of a structural model is problematic. For this reason, most previous studies use regression analysis to estimate the reduced form equilibrium of VC, which does not require the identification of variables affecting only demand or supply.

A first group of studies on this subject used regression analysis to estimate the reduced form equilibrium of VC activity and to identify the main determinants of VC activity. This group includes the studies by Jeng and Wells (2000), Schertler (2003), Romain and de La Potterie (2004), Parris (2007), Félix, Pires and Gulamhussen (2007, 2013) and Fuss and Schweizer (2009).

A second group of research (Gompers and Lerner 1998a; Bonini and Aktuccar 2009; Clarysse, Knockaert, and Wright 2009; Kelly 2010) does not explicitly mention an equilibrium framework. However, the dependent variable used to denote supply and demand is the same. Hence, implicitly these papers study the market in an equilibrium state.

In a third group, some related papers do not follow a reduced-form approach. For instance, Marti and Balboa (2001) emphasize VC funding including VC investments as an explanatory variable, Leleux and Surlemont (2003) analyze the development of the VC market using cumulative funds raising as an explanatory variable, Rin, Nicodano, and Sembenelli (2006) analyze the effectiveness of public policy instruments using innovation ratios as an explanatory variable and Schertler (2007) analyzes VC investment including previous VC funding as an explanatory variable.

Armour and Cumming (2006), using simultaneous equation models, tried to analyze the impact of the legal environment, government funds and personal bankruptcy on the VC market. Nevertheless, this study did not focus on the determinants of the VC market but used some traditional determinants as control variables.

Hong, Serfes, and Thiele (2020) analyzed the effect of a competitive supply of venture capital (VC) on exits, through the initial public offering or mergers and acquisitions, of startups. They developed a model with double-sided moral hazard, identifying a differential effect of VC competition on the success of startups.

Our work also uses simultaneous equation models (trying to clearly distinguish the determinants that affect VC demand from those affecting VC supply), but based on previous work, studies how market concentration affects the VC market. Our work is distinguished from that of Hong, Serfes, and Thiele (2020) in terms of the intended objective (as well as partly by the methodologies used). While Hong, Serfes, and Thiele (2020) intended to examine how competition in the market for VC affects the likelihood of funded companies experiencing a successful exit (IPO or M&A), our study aims to examine the impact of market concentration in VCs on the supply of venture capital. Therefore, our work focuses on the impact of VC market structure on VC supply, whereas Hong, Serfes,

and Thiele (2020) focus on the impact in terms of the exits of VC investments already made.

In this section we identify the variables that represent the VC supply and demand (dependent variables) as well as the potential determinants of VC activity (independent variables).

As already mentioned, VC demand comes from entrepreneurs who need funds for their projects. In other words, demand is based on the quantity and quality of innovative companies in need of VC. On the other side of the market, VC supply comes from the willingness and ability of investors (banks, pension funds, insurance companies, academic institutions, funds of funds, corporate investors, government agencies and private investors) to provide funds to VCs, and VCs' willingness and ability to provide funds to innovative companies.

As a variable representing the VC demand and VC supply we use annual Venture Capital total investment as per mil of GDP. In order to homogenize the data, we normalize the dependent variable according to the value of GDP in the current year in each country. We follow this procedure, already used by Marti and Balboa (2001) and Félix, Pires, and Gulamhussen (2013), for two reasons. First, this procedure solves the problem of heteroskedasticity derived from the existence of different levels of economic development among countries (larger economies tend to have greater variability in the observed data). Second, all variables are originally expressed in current prices. This procedure allows us not only to overcome the problem of the existence of inflation in each country over time, but also different inflation rates between countries.

This section identifies the variables that influence the demand and/or supply, and explain, based on theoretical arguments, the mechanisms by which each variable affects demand and/or supply.

On the demand side there are two mechanisms that must be considered:

d_1) how the variable affects the creation of new businesses; and

d_2) how the variable affects the financing decision.

On the supply side the following mechanisms have to be considered:

s_1) how the variable affects the amount of funds available for investment in VC;

s_2) how the variable influences portfolio selection and, in particular, the proportion that is invested in VC.

Necessarily, the model includes most of the factors suggested by the theory as control variables and introduces the Herfindahl – Hirschman index (HHI) as a proxy of the degree of concentration among VCs. It includes GDP real growth rate and market capitalization growth as proxies for expectations about the economy; stock market capitalization as a proxy for depth and liquidity of stock markets; the long-term interest rate as a proxy of the cost of an alternative to VC financing (credit); the unemployment rate; IPO, trade sale and write-offs divestment as proxies of exit conditions; R&D capital stock and Improvement-Driven Opportunity Entrepreneurial Activity index (Opportunity-TEA) as proxies of technological opportunities and entrepreneurial activity; and personal income tax rate and the EVCA tax and legal index as proxies of the fiscal and legal environment.

2.2 Concentration among venture capitalists

The relationship between the structure and activity of a market is one of the classic topics of Industrial Economics.

Concentration and competition between VCs have been studied. Inderst and Muller (2000) and Inderst (2001) analyze the relationship between competition and contract design. Anton and Yao (1994) and Casamatta and Haritchabalet (2004) analyze how the entrepreneur can use competition between VCs to extract innovation rents. Li and Mahoney (2011) look at how competition between VCs in an industry influences the initiation of venture capital projects. Hyytinen and Toivanen (2003) studied a horizontally differentiated market for financial intermediation and developed a simple explanation for concentration in the financial intermediation industry applied to the VC market.

The structure of competition in the VC market is referenced by Hellmann and Puri (2002, 22) during the mid-1990s with the explosion of the Internet. They argue that the nature of competition between venture capitalists altered during this period. *There was massive new entry into the industry (. . .) and VCs invested in many more companies and tried to place larger sums of money into their portfolio companies (. . .)*.

Mason and Harrison (2002) reviewed the regional distribution of VC investments in the UK in the 1990s, noting that there were differences depending on geographical space. They observed a temporal evolution in the shift of investment in VC, but clearly the type of investment in VC that was being carried out was dependent on the resources existing in the region, as well as the type of business that emerged.

In 2007, Christensen studied how geographical specialization, or diversification, happens in an underdeveloped and growing venture capital industry. The author concluded that the geographical specialization of VCs may pursue a non-linear pattern involving several phases. The study shows that the competition and the need to construct competencies, of VCs, can result in concentration. This study concluded that competence-based theory explains better the pattern of VC specialization than the traditional financial theory.

Chen et al. (2010) analyzed the geographical concentration of VCs in three American areas (San Francisco, New York, and Boston), finding that the success rate of VC investments in a region is an important determinant of venture capital firms' decisions to open new branches. After a VC makes more than one investment in a region, the performance disparity between local and non-local investments vanishes, which seems to suggest decreasing marginal monitoring cost (that is, VCs may reduce their expected success rate for investment in a more distant location).

Colombo, D'Adda, and Quas (2018) studied how the propensity to seek external equity from European high-tech companies was affected by the geographical distribution of VC. They noted that companies located in the proximity of regions where the VC market is most developed are more likely to search for external equity, while the concentration of the local VC market plays a negligible role.

Hong, Serfes, and Thiele (2020) examined how competition in the market for VC affects the likelihood of funded companies experiencing a successful exit (IPO and Trade Sale), and concluded that as the VC market becomes more competitive, companies funded by VC firms that have an experience below the 90th percentile have a higher likelihood of a successful exit.

Competition between VCs occurs both upstream and downstream. Venture capitalists compete for funds and worthwhile ventures. In our work, we explore the concentration among VCs for promising investment opportunities as a potential determinant of the VC market. Theoretically, the competition among VCs influences supply in the market. Following competence-based theory, higher competition

between VCs is expected to lead to greater specialization, and thus to less concentration, but a greater supply of funds. Our study follows the conclusions of McNaughton (1989) and Christensen (2007), who concluded that the concentration of VC sources in a market is inversely related to the size of the market. So, we will argue that supply is greater (s_1) the lower the concentration among VCs.

To analyze the degree of concentration in the VC market we use the Herfindahl – Hirschman index (HHI) (Hirschman 1964), similarly to Hong, Serfes, and Thiele (2020). Internationalization of the VC market implies that part of the investment within a country is derived from VC firms located in other countries. For this reason, we use as a measure of concentration an *HHI* calculated based on the investments in a country regardless of the origin of the VC firm:

$$HHI = \sum_{j=1}^{m} \left[\frac{I_j}{\sum_{j=1}^{m} I_j} \right]^2 \tag{1}$$

where I_j is the amount invested by venture capitalist j (with $j = 1, 2, \cdots, m$) and m is the number of VCs who invested in the country. A higher value of *HHI* indicates higher concentration and thus a lower level of competition among VCs. So, we expect that the higher the value of the index, the lower the VC supply (s_1).

2.3 Control variables

Real GDP annual growth rate

The existing literature considers that the state of the economy influences the VC market. GDP (Gompers and Lerner 1998a; Jeng and Wells 2000), GDP growth rate (Gompers and Lerner 1998a; Jeng and Wells 2000; Marti and Balboa 2001; Romain and de La Potterie 2004; Armour and Cumming 2006; Félix, Pires, and Gulamhussen 2007, 2013; Schertler 2007; Bonini and Aktuccar 2009), industrial production (Fuss and Schweizer 2009) and GDP per capita (Chen et al. 2010) were some of the variables included in previous studies that sought to reflect the state of the economy.

We use real annual GDP growth rate (GDPgr) as a measure that reflects the state of the economy. Previous work has found that GDP growth generates investment opportunities leading to the creation of new start-ups requiring VC funds (d_1). We therefore expect a positive impact of GDP growth on the demand for VC. As pointed out by Romain and de La Potterie (2004), GDP growth is also related to periods of high profitability resulting from divestments in this activity. Jeng and Wells (2000) also consider a positive effect of GDP growth on VC supply. Thus, we expect a positive relationship between GDP growth and the supply of funds for venture capital (s_1).

Market capitalization growth

As suggested by Jeng and Wells (2000) and Félix, Pires, and Gulamhussen (2007, 2013), market capitalization growth (MCgr) is another determinant of VC activity related to the state of the economy. On the demand side, increases in market capitalization growth correspond to good expectations for the economy, leading to the creation of new start-

ups which need venture capital funds (d_1). So, we expect a positive impact of market capitalization growth on demand for VC.

On the supply side, the effect is ambiguous. On the one hand, increases in market capitalization growth correspond to good expectations for the economy and a consequent increase in the available funds for VC investments (s_1). On the other hand, the public market acts as a substitute for VC. High returns in the public market may lead to decreases in VC investments because investors may prefer to invest in the stock market (s_2).

Stock market capitalization

VC tends to develop in countries with deep and liquid stock markets (see Black and Gilson 1999; Gompers and Lerner 2000). This has been considered in previous work on VC determinants. The variables used to measure the depth and liquidity of stock markets were stock market capitalization scaled by GDP (Schertler 2003; Clarysse, Knockaert, and Wright 2009; Kelly 2010) and the number of listed firms scaled by total population and total labor force (Schertler 2003).

We argue that a deep and liquid stock market increases the likelihood of investors recovering their investment (s_1). Thus, we expect a positive relationship between stock market capitalization (SMC) and the supply of funds for VC.

To measure stock market depth and liquidity, we used stock market capitalization as a percentage of GDP.

Long-term lending interest rate

Theoretically, the level of interest rates affects the supply and demand of VC because it is an investment alternative for the investor and a financing alternative for the entrepreneur.

The effect of the interest rate on VC demand is ambiguous. On the one hand, to obtain funding through VC the entrepreneur must have at least the genesis of the product and a credible business plan. The funds to cover this phase will come from personal finances, family and friends or a personal bank credit. In both situations, an increased interest rate reduces the desire to create a new company (d_1). On the other hand, from the entrepreneur's point of view, an increased interest rate makes VC financing more attractive than bank credit (Gompers and Lerner 1998a; Romain and de La Potterie 2004; Fuss and Schweizer 2009). Thus, in this case, we expect a positive relationship between the interest rate and the demand for VC funds (d_2).

From the investor's perspective, the interest rate can be seen as an alternative to the application of money. An increased interest rate reduces the attractiveness of risky investments such as VC (Gompers and Lerner 1998a; Romain and de La Potterie 2004; Bonini and Aktuccar 2009; Fuss and Schweizer 2009). So, we expect a negative relationship between the interest rate and the supply of funds for VC (s_2).

In the previous literature, various types of interest rate have been used as potential determinants of VC activity: short-term interest rate (Gompers and Lerner 1998a; Romain and de La Potterie 2004; Schertler 2007; Clarysse, Knockaert, and Wright 2009; Fuss and Schweizer 2009), long-term interest rate (Romain and de La Potterie 2004; Schertler 2007; Félix, Pires, and Gulamhussen 2007, 2013; Fuss and Schweizer 2009), real interest rate and interest rate difference (Romain and de La Potterie 2004).

In this study, we used the long-term interest rate (IR). Theoretically, it is the most relevant in investment or financial decision-making since VCs hold their investments for a period of 3–7 years.

Labor market

The unemployment rate (UR) has been used as a potential determinant of VC activity in the previous literature (Félix, Pires, and Gulamhussen 2007, 2013; Clarysse, Knockaert, and Wright 2009; Kelly 2010).

The effect of unemployment rate on VC demand is ambiguous. For an employed individual, a high unemployment rate discourages entrepreneurial activity through creating their own business (d_1) because in the case of failure, the time taken to find a new job may be longer. For that reason, we expect a negative relationship between the unemployment rate and the demand for VC funds. However, for an unemployed individual, a high rate of unemployment lowers the opportunity cost of creating their own job (d_1). Thus, we expect a positive relationship between the unemployment rate and demand for VC funds.

IPO, trade sale and write-offs divestment

The last phase of investment in the VC market is the exit or divestment. VCs will divest their holdings in order to make gains from the investment made (Gompers 2005). *VCs typically hold their investments for a period of between 3–7 years after which successful investments are exited either listing the company through an initial public offering (IPO) or by selling the company to a competitor (trade sale). Unsuccessful investments are liquidated* (Armour and Cumming 2006, 2).

From the investor's point of view, the existence of the IPO exit mechanism increases the possibility of recovering their investment. In addition, the IPO is typically the most profitable form of exit (Gompers 2005). For this reason, most studies on this subject include the IPO as a determinant of VC investment (e.g., Gompers and Lerner 1998a; Jeng and Wells 2000; Félix, Pires, and Gulamhussen 2007; Fuss and Schweizer 2009; Bonini and Aktuccar 2009). So, we expect a positive relationship between annual IPO divestment and the supply of VC funds (s_1).

From the entrepreneur's point of view, the existence of the IPO exit channel is an additional incentive to start a company (d_1) because it provides a way to financially recover the effort made (Jeng and Wells 2000). More than that, the special skills of the VCs in preparing portfolio companies to go public are an incentive for entrepreneurs to choose to finance themselves through VCs (d_2). So, we expect a positive relationship between annual IPO divestment and the demand for VC funds.

A trade sale is a form of exit channel consisting of the sale of the VC's share to strategic investors, or other VCs, while entrepreneurs keep their share.

Given its importance in the European market we decided, like Félix, Pires, and Gulamhussen (2007), to include this variable as a possible determinant of VC activity. So, we expect a positive relationship between annual trade sales divestment and supply of VC funds (s_1).

The existence of this exit channel allows the entrepreneur to consider the future possibility of continuing to have a partner in developing the project (d_2). So, we expect annual trade sales divestment to increase VC demand.

Write-offs (WO) are an exit channel with a greater impact in Europe. This happens when investments do not succeed. So, we expect a negative relationship between annual write-offs divestment and the demand and supply of VC funds (s_1).

Research and development (R&D) capital stock

One determinant that has been tested is technological opportunities. Several measures have been used to capture the effect of this factor on VC activity: R&D expenditure (e.g., Gompers and Lerner 1998a; Schertler 2007; Félix, Pires, and Gulamhussen 2007, 2013; Parris 2007; Clarysse, Knockaert, and Wright 2009; Kelly 2010), business R&D expenditure (Bonini and Aktuccar 2009), business R&D expenditure growth (Romain and de La Potterie 2004), number of triadic patents (Romain and de La Potterie 2004), number of patent applications (Armour and Cumming 2006; Schertler 2007), the number of R&D employees (Schertler 2007) and number of R&D researchers (Schertler 2007).

We use R&D capital stock as a proxy for technological opportunities, because as Romain and de La Potterie (2004, 10) argued, it is an indicator of the available stock of knowledge (or of cumulated innovative efforts). This measure will be divided into two variables: Public R&D capital stock (PRD) and Business R&D capital stock (BRD). Public R&D capital stock (PRD) is the amount of R&D expenditure by the government, and Business R&D capital stock (BRD) the amount of R&D expenditure by private investors. We argue that Public R&D capital stock is most widely used in projects that are in their seed stage (they take longer to be funded by VC) while Business R&D capital stock is more used in projects at the start-up stage (they take less time to be funded by VC).

Gompers and Lerner (1998) argued that the growth of funds available for VC investments in the 90s, in the USA, was due to increased technological opportunities. So, we expect a positive relationship between technological opportunities, as measured by R&D capital stock, and supply of VC funds (s_1 and s_2).

We also argue that an increase in R&D capital stock may mean there are more entrepreneurs with innovative ideas who need VC funding (d_1 and d_2).

Public and business R&D capital stock RD_{it} (measured at the end of period t) in real terms is computed by a perpetual inventory method with a constant rate of depreciation ($\delta = 0.15$). The values of R&D public and business expenditure in euros at current prices (R_{it}) are available for each country since 1981 from EUROSTAT AMECO database. We deflate these data by using an inflation tax rate from the OECD database (P_{it}). The public and business R&D capital stock for the first year used in estimation (RD_{i92}) is then calculated by summing up the real expenditure from 1981 to 1992 appropriately depreciated:

$$RD_{i92} = \sum_{t=1981}^{1992} \left(\frac{R_{it}}{P_{it}}\right)(1-\delta)^{1992-t} \tag{2}$$

The equation used for the subsequent years is:

$$RD_{it} = (1-\delta)RD_{it-1} + \frac{R_{it}}{P_{it}}, t = 1993, \cdots, 2009 \tag{3}$$

Opportunity-TEA (improvement-driven opportunity entrepreneurial activity)

VCs play an important role as intermediaries in financial markets, providing capital to entrepreneurs who would otherwise have difficulty in attracting funding (Gompers and Lerner 2000). This strong relationship between VC and entrepreneurship has been emphasized by several studies. In the literature on VC determinants, Romain and de La Potterie (2004), Félix, Pires, and Gulamhussen (2007, 2013), Clarysse, Knockaert, and Wright (2009) and Bonini and Aktuccar (2009) include entrepreneurial activity as a proxy that could explain VC activity. The measure of entrepreneurial activity used was TEA (*Total entrepreneurial activity index*). The TEA is computed by Global Entrepreneurship Monitor (GEM) and measures a country's entrepreneurial activity, and can be used for international comparisons. This index encompasses the proportion of adults involved in creating emerging firms and the proportion involved in new firms. This variable ranges from 1 to 20, with 1 indicating the lowest level of entrepreneurial activity.

We argue that this variable does not accurately measure a country's entrepreneurial activity, because the TEA encompasses two measures: Improvement-Driven Opportunity Entrepreneurial Activity (Percentage of those involved in TEA who (i) claim to be driven by opportunity as opposed to finding no other option for work; and (ii) those indicating that the main driver of being involved in this opportunity is to be independent or increase their income, instead of just maintaining their income) and Necessity-Driven Entrepreneurial Activity (Percentage of those involved in TEA who are involved in entrepreneurship because they had no other employment option). The definitions themselves indicate that the measure that really explains the demand for venture capital financing is the Improvement-Driven Opportunity Entrepreneurial Activity (OTEA). So, we will use it as a possible determinant of VC activity, expecting a positive relationship between the value of this variable and the creation of new businesses (d_1) with innovative projects that are usually financed by VC (d_2).

Fiscal and legal determinants

Each country's tax system is a key factor in the development of any economic activity, including CV activity. In our work, we consider that personal income tax rate can influence this activity.

The impact of personal tax rate (*Pitx*) on the level of entrepreneurship and VC activity has been examined in several studies. Bruce and Gurley (2004) conclude that a higher personal income tax rate increases entrepreneurial activity as more workers move from wage-and-salary work to start their own business (d_1). In addition, Gordon (1998), Rin, Nicodano, and Sembenelli (2006) and Cullen and Gordon (2007) suggest that increases in individuals' personal tax push them into becoming entrepreneurs (d_1). So, we expect that a higher personal income tax rate will promote entrepreneurship and raise the demand for VC.

The existence of adequate laws to protect VC investments and the investor's funds has attracted the attention of researchers. Cumming, Schmidt, and Walz (2006) analyze the impact of the legal environment on the governance of investments in the private equity industry. Jeng and Wells (2000) and Leleux and Surlemont (2003), based on La Porta et al. (1997, 1998), use minority shareholder rights, antidirector rights and credit rights as possible determinants of VC activity.

Indeed, capital gains taxes correlate negatively with the supply of CV financing, as expecting lower exit returns, investors have fewer incentives to feed their portfolio companies (Gompers and Lerner 1998b; Murtinu 2021).

Theoretically, the supply will be higher in countries with a legal environment that protects investors' funds and investments made by VCs (s_1). To capture the effect of the legal environment on the VC market, as in Armour and Cumming (2006) and Kelly (2010), we use the fiscal and legal index of EVCA because it is directly related to VC activity.

According to Invest Europe, this index is based on seven criteria split in 30 variables that are determinant for the good functioning of the private equity and venture capital ecosystem. The EVCA index is structured so that a lower number indicates a better legal and tax environment for VC activity. So, we expect a negative relationship between the EVCA index and supply of VC funds (s_1).

Table A1, in Appendix 1, identifies the potential VC determinants and the expected effect on the demand and/or supply.

3 Data and methodology

3.1 Data sources

Our analysis is based on a panel of data gathered from several sources. We consider data for the following 15 European countries: Austria; Belgium; Denmark; Finland; France; Germany; Ireland; Italy; Netherlands; Norway; Portugal; Spain; Sweden; Switzerland and the United Kingdom for the years between 1992 and 2009 (18 years). We work with a balanced panel data set with 270 observations.

Our source for the *dependent variable* is the Invest Europe (former European Private Equity and Venture Capital Association – EVCA). For each year and country, the amount of total investment according to Invest Europe, is divided into seven categories: seed, start-up, later stage venture, growth, rescue/turnaround, replacement capital and buyouts. Our dependent variable, *Venture Capital investment*, is the sum of seed, start-up and later stage ventures.

Regarding the *independent variables* (exogenous and endogenous) we use different sources (e.g., Invest Europe Yearbooks, database AMECO from Eurostat, World Bank database, OECD database, Global Entrepreneurship Monitor (GEM), worldwide corporate tax guide from Ernst and Young and VentureXpert´s database from Thomson Financials).

Table A2, in Appendix 1, presents the variables, their respective meanings, database sources and the authors who have studied the relationship. Table A3,[1] in Appendix 1, presents the descriptive statistics and the correlation matrix.

This article analyzes the impact of the level of concentration among VCs on the supply of VC, through the reduced form model for the equilibrium amount of venture capital, using a simultaneous equation model on aggregated data from 15 European countries.

Methodology

Seeking to analyze the impact of the level of concentration among VCs on the supply of VC, this study employs a simultaneous equation method by using a two-stage least-squares framework, separately estimating VC supply and demand. In this case we use a log-log specification for model estimation and also use dummy country variables.

Following the studies that used the reduced form model[2], we assumed the equilibrium condition, and therefore, the amount of VC demand is equal to the amount of VC supply (and this is given by the variable of *Venture Capital investment*).

The use of two-stage least-squares models, which apply instrumental variables, allows control of the possible existence of endogeneity (namely, when we study market concentration).

In a supply and demand model, besides the quantity, the return is also an endogenous variable. However, finding a measure of return in the VC market is not an easy task. Armour and Cumming (2006) refer to the Morgan Stanley Capital International index of stock market returns (*MSCI)* as an equilibrium mechanism but then they do not consider this variable as endogenous in their analysis.

As a measure of the VC return (endogenous variable) we use the pooled internal rate of return (*IRRpool*), which is the interim net return earned by investors from a fund (a more detailed description is presented in Table A2). Theoretically an increase in *IRRpool* leads to an increase in VC supply, so we expect a positive relationship between *IRRpool* and the supply of VC. On the demand side, for a given total return on investment, the higher the cost of capital for the entrepreneur, the lower the return for the entrepreneur. So, we expect a negative relationship between *IRRpool* and the demand for VC.

This methodology is a straightforward application of well-known techniques for the simultaneous econometric estimation of demand and supply:

$$\begin{aligned} lnVCSupply_{it} &= \alpha_0 + \alpha_1 lnIRRpool_{it} + \alpha_2 lnHHI_{it} + \alpha_3 lnGDPgr_{it} + \alpha_4 lnMCgr_{it} \\ &+ \alpha_5 lnSMC_{it} + \alpha_6 lnIR_{it} + \alpha_7 lnTsale_{it} + \alpha_8 lnIPO_{it} + \alpha_9 lnWO_{it} \\ &+ \alpha_{10} lnPRD_{it} + \alpha_{11} lnBRD_{it} + \alpha_{12} lnEVCAindex_{it} + \varepsilon_1 \end{aligned} \tag{4}$$

$$\begin{aligned} lnVCDemand_{it} &= \beta_0 + \beta_1 lnIRRpool_{it} + \beta_2 lnGDPgr_{it} + \beta_3 lnMCgr_{it} + \beta_4 lnIR_{it} \\ &+ \beta_5 lnUR_{it} + \beta_6 lnTsale_{it} + \beta_7 lnIPO_{it} + \beta_8 lnWO_{it} + \beta_9 lnPRD_{it} \\ &+ \beta_{10} lnBRD_{it} + \beta_{11} lnOTEA_{it} + \beta_{12} lnPltx_{it} + \varepsilon_2 \end{aligned} \tag{5}$$

Although there is a considerable overlap between the variables in the supply and demand equations, such equations are fully capable of being estimated as long as there is at least one variable that differs between the two equations (see, e.g., Judge et al. 1988). This criterion is satisfied. The variables of *SMC*, *EVCAindex* and *HHI* are unique to the supply equation, and the *UR*, *OTEA* and *Pitx* variables are unique to the demand equation. These variables work as instruments (instrumental variables should be correlated with the equation´s endogenous variable, but uncorrelated with the other potential endogenous variables and also uncorrelated with the error term). For the demand models, the *HHI*, *SMC* and *EVCAindex* were the instruments used and for the supply models the *UR*, *OTEA* and *Pitx*. We test different models where we used one or more instruments. In the last case, the model is overidentified, meaning that the number of additional instruments exceeds the number of endogenous regressors, and then we use the Sargan´s test to check whether the instruments are uncorrelated with the error term. If the p-value is above 10% we do not reject the null hypothesis that the

instruments are uncorrelated with the error term, suggesting that we should be satisfied with this specification of the equation.

Another question is to ask if a variable presumed to be endogenous (*IRRpool* in our case) could instead be treated as exogenous. We used the Wu – Hausman tests where the null hypothesis is that the variable under consideration can be treated as exogenous. If the p-value is below 10% we reject the null hypothesis.

We also intend to test our results for possible omitted variable bias. According to Oster (2019), concerns about omitted variable bias are common to most or all non-experimental work in economics. Sometimes it is possible to find a control (or several) that fully captures a given omitted variable, but in many cases the observed controls are an incomplete proxy for the true omitted variable or variables. So, we will apply the methodology developed by Oster (2019), as in Murtinu (2021).

We will implement the application according to assumption 3, by Oster (2019), who argues that if $\delta = 1$ then there is a unique solution, which is consistent with the work of Altonji, Elder, and Taber (2005). It was therefore assumed that a relationship between the regressors of interest (*IRRpool*) and the omitted variables can be estimated from the relationship between the regressors of interest and the other regressors included in the model specification. There will be an upper bound to the proportion of variance explained by unobserved variables over the variance explained by observed variables, which will be one. This upper bound means that the variance explained by unobserved variables needs to match the variance explained by regressors to make the estimated findings vanish. The upper bound will be set as RMAX, which is the ideal R2 that would be obtained when the dependent variable is regressed against the variables included in the model specification, and the omitted variables. We will set RMAX equal to 1.3 times the value of the R2 obtained after estimating the main model specification (according to Oster 2019). Next, we will calculate the delta parameter (which is the proportion of variance explained by unobserved variables over the variance explained by observed variables) necessary to nullify the estimated results. According to assumption 3, by Oster (2019), if delta is greater than one (the upper bound), it can be safely said that the presence of an omitted variable bias is unlikely (Murtinu 2021, 292).

The identification of switch points is also important, and we will test our data for their possible existence. According to Arin et al. (2022), inflection points, kinks, and jumps allow us to identify places where the relationship between dependent and independent variables switches in some important way. The identification of endogenous switch points may lead to significantly different conclusions from those obtained when switch points are ignored or their existence is conjectured arbitrarily (Arin et al. 2022, 1). We will apply the methodology developed by Arin et al. (2022) to all variables used and analyze the results obtained.

4 Empirical results

This section describes the estimation of the Simultaneous Equation Model and discusses the main results (Table A4). A two-stage least-squares approach was used to estimate VC supply and demand separately. The log-log specification was used to estimate the model, where natural logarithms are taken on both sides of the equation. This approach has the

advantage that coefficients can be interpreted as elasticity. The coefficient values indicate the percentage variation of the dependent variable resulting from an increase of 1% of the independent variable.

We test different models where we use one or more instruments. Models 1, 2 and 3 estimate the VC demand and models 4 and 5 estimate venture capital supply. In all cases, the results of the Sargan tests lead us to conclude that we should be satisfied with the specification of the equations and instruments used. Also, through the Wald test we can conclude that all the estimated models have a strong overall significance.

Let us analyze the impact of each variable on the models. The pooled internal rate of return (*IRRpool*) is used as an endogenous variable and represents, in the system, an equilibrium mechanism. As expected, this variable has a negative and statistically significant impact, at 1%, on demand. As we argued, for a given total return on investment, the higher the cost of capital to the entrepreneur, the lower the return for the entrepreneur. On the supply side, the variable has no statistically significant effect. This result suggests that the supply curve is vertical (perfectly inelastic). The Wu – Hausman test leads us to reject the null hypothesis that the pooled internal rate of return can be treated as exogenous.

Regarding exogenous variables, the concentration between VCs (*HHI*) has, as expected, a strong (p-value <1%) significant impact on VC supply. When this index decreases by 1% the VC supply increases by approximately 0.3%. As we argued before, we have confirmed our hypothesis that a lower concentration among VCs brings a greater supply of funds. Leading us to conclude that the creation of conditions to reduce market concentration can stimulate the supply of VC.

GDP growth (*GDPgr*), as expected, has a positive and statistically significant impact on both demand and supply, at a level of 1% for demand and 10% for supply. A 1% increase in *GDPgr*, leads to an increase of more than 0.59% in VC demand and more than 0.18% in VC supply. These results are consistent with the results obtained by Gompers and Lerner (1998), Romain and de La Potterie (2004), Félix, Pires, and Gulamhussen (2007, 2013) and Schertler (2007).

The growth of market capitalization (MCgr), as in the work of Jeng and Wells (2000) and Félix, Pires, and Gulamhussen (2007), does not have a statistically significant impact on VC activity (demand and supply).

Stock market capitalization (*SMC*) has a positive impact on both supply models, which means that VC supply tends to develop in countries with deep and liquid stock markets. In the supply model, where the coefficient is statistically significant, a 1% increase in *SMC* leads to a 0.26% increase in VC supply. These results are according to the theory and the results obtained by Schertler (2003), Clarysse, Knockaert, and Wright (2009) and Kelly (2010).

Although the interest rate (*IR*) may be seen as the return of an investment alternative to the investor and the cost of a financing alternative to the entrepreneur, this variable is not statistically significant, as in Schertler (2007).

The unemployment rate (*UR*) has a negative and significant effect, at a 10% level, on all VC demand models. This result is in line with the work of Félix, Pires, and Gulamhussen (2007, 2013) and Kelly (2010). This means that the effect for an employed individual, where a higher unemployment rate discourages entrepreneurial activity because in the event of failure it may take longer to find a new job, is greater than the effect for an

unemployed individual, where a higher unemployment rate lowers the opportunity cost of creating their own job.

IPO and *Trade sales* (TSale) have a positive and statistically significant impact, at a level of 10%, on VC demand and supply, which reflects the importance of an exit channel for entrepreneurs and VC firms. This result is consistent with the results obtained by Félix, Pires, and Gulamhussen (2007, 2013) and Fuss and Schweizer (2009). In our case, this impact is also significant in most of the estimated models. It is also possible to observe that a 1% increase in trade sales causes a higher percentage increase in VC supply and demand than the same increase in *IPO*. This result is justified because a trade sale is Europe's main exit channel.

The other form of divestment *Write-offs* (*WO*), does not have a statistically significant impact on VC demand and a positive impact on VC supply. As we argued earlier, this surprising result can probably be explained by the fact that, given the high risk in the VC market, VCs are aware that some businesses are naturally not successful. Abandoning these unsuccessful ventures frees the venture capitalist to allocate efforts in new projects.

Public and business R&D capital stock has been used as proxies of technological opportunities and has opposite results. Surprisingly, public R&D capital stock (*PRD*) has a statistically significant and negative impact on VC supply and demand, an unexpected result. Business R&D capital stock (*BRD*) has the expected and statistically significant positive impact on VC demand and supply. This variable also has a strong impact (p-value <1%) on VC demand. Moreover, among all the potential determinants used in our study, this is what has the greatest effect on VC supply and demand.

The Improvement-Driven Opportunity Entrepreneurial Activity (OTEA) was used in the literature as a measure of entrepreneurial activity. The results were ambiguous, as Félix, Pires, and Gulamhussen (2007, 2013) found a negative effect of this variable on the VC market, while Bonini and Aktuccar (2009) and Clarysse, Knockaert, and Wright (2009) found a positive effect. Although we use a variable more appropriate to this market (*OTEA*), the results are not conclusive because the coefficients in all the estimated demand models have no statistical significance.

As expected, the personal income tax rate (*Pitx*) has a significant positive and statistical effect on VC demand. A higher personal income tax rate can foster entrepreneurship and increase demand for venture capital because more workers move from wage-and-salary work to start their own business. In addition, other studies (e.g., Gordon (1998), Rin, Nicodano, and Sembenelli (2006) and Cullen and Gordon (2007)) suggest that increased personal taxation encourages individuals to become entrepreneurs. The results obtained suggest that a 1% increase in *Pitx* increases the demand for VC by more than 1.2%.

The *EVCA index* is structured in such a way that the lower number indicates a better legal and tax environment for VC activity. The *EVCA index* has a surprising positive and significant coefficient of 5%. It seems that a favorable legal and tax VC environment decreases the supply of VC. One possible explanation for these results is that the VCs invest in projects due to their high potential probability rather than fiscal advantages. To accentuate this idea, it should be noted that Kelly (2010) obtained a positive (though without statistical significance) relationship between capital gains tax rate and VC activity. Another possible explanation is that the *EVCA index* is based on criteria that determine the proper functioning not only of the venture capital ecosystem but also of the private equity ecosystem. For example, quantitative or qualitative restrictions that prevent or

limit insurance companies' investments in private equity, and geographical restrictions for pension funds to invest in private equity and venture in other European countries, are components of the *EVCA index*. But our work is just about VC and not about private equity. So, this index encompasses criteria that are not related to the VC market, but probably influence our analysis.

Overall, our results indicate that government intervention to boost the market is more effective by creating mechanisms to reduce the concentration in the VC market than through public investments in R&D and fiscal mechanisms.

5 Robustness checks: omitted variable bias

Looking at the value of the Sargan test in Table A4 in Appendix 1, we see that in all cases, the test results lead us to conclude that we should be satisfied with the specification of the equations and of the instruments used.

Regarding our endogenous variable (*IRRpool*), which allows us to perform the equilibrium condition for demand and supply equations, the Wu-Hausman test values, in Table A4, allow us to conclude that that variable cannot be treated as exogenous.

Turning now to Table A5, models 1 and 2 are the results for the fixed effects panel data models for the model with all the regressors (model 1 excludes the endogenous variable, model 2 includes it). We perform these fixed effects panel data models because they allow us to take care of time-invariant market-specific omitted variables (Hochberg, Ljungqvist, and Lu 2010). In both models, all the tests allow us to conclude on consistency, so we can analyze the results. Overall, almost all the variables maintain the impacts on the dependent variable, with it being important to note that the *HHI* variable remains statistically significant, at 1% significance, and with the impact that confirms our hypothesis, that a lower concentration among VCs brings a higher supply of funds.

These two models were intended to apply the methodology developed by Oster (2019), as presented in section 3.2. We conclude that the presence of omitted variable bias in our data seems unlikely. The delta value is 7.94, greater than 1, so it would be necessary for unobserved variables to explain 7.94 times the variance explained by regressors included in the model specification to make the estimated findings null. The value of the delta is greater than 1, confirming Oster's assumption 3 (Oster 2019), which allows us to conclude on the possible existence of a single solution.

6 Discussion and conclusion

This article analyzed the impact of the level of VC concentration on the supply of venture capital, using a Simultaneous Equation Model (which allows distinguishing the determinants that affect VC demand from determinants affecting VC supply), with a data set for 15 European countries for the period from 1992 to 2009.

We introduce the concentration structure in the VC market as a potential factor of VC supply. In this case, we tested whether concentration between VCs, through the Herfindahl – Hirschman Index, is an important factor in explaining VC supply. We introduced, for the first time, a measure of entrepreneurship level that clearly separates individuals who become entrepreneurs because they have found an opportunity, from

those who have become entrepreneurs out of necessity. We tested the improvement-Driven Opportunity Entrepreneurial Activity as a factor to explain the demand for VC. Our empirical model includes many of the determinants already tested in previous studies as control variables (GDP growth rate, market capitalization growth, stock market capitalization, long term real interest rate, unemployment rate, trade sales, IPO and write-offs divestments, public and business research and development capital stock, personal income tax rate and EVCA tax and legal index).

The results prove that the level of concentration among VCs is a determinant of VC supply, so a lower concentration will bring a greater supply of funds.

Overall, the evidence suggests that the state of the economy (real positive GDP growth rate), the existence of exit mechanisms that increase the possibility of recovering the investment (trade sales and IPO) and the existence of technological opportunities (business R&D capital stock) improve the VC market (both demand and supply).

Our estimates show that the direct impact of write-offs divestments on VC supply is positive. At first glance, this result is surprising, as we expect VC supply to be declining with write-offs divestments. However, we must not forget that VC is especially oriented towards innovative projects and this surprising result can probably be explained by the fact that VCs are aware that, given the high risk in the VC market, some businesses are naturally not successful.

Business and public R&D capital stock have opposite effects on VC investment. The business R&D capital stock has a strong positive impact on VC demand and supply. Surprisingly, public R&D capital stock has a negative impact on VC demand and supply, one possible explanation being that public spending deviates funds from the private VC market. On the other hand, if the government makes R&D investments, entrepreneurs who may be interested in developing such projects do not do so because the government is their competitor/employer. In this way, policies that stimulate R&D business should be considered by governments.

On the demand side, the unemployment rate has a negative effect on VC investment (a high unemployment rate discourages entrepreneurial activity) and the personal income tax rate has a positive effect on VC demand (a higher personal income tax rate can foster entrepreneurship because more workers move from wage-and-salary work to start their own business).

On the supply side, VC tends to develop in countries with deep and liquid stock markets. In addition, our study shows that lower levels of concentration among VCs are an important factor in explaining VC supply, confirming that lower concentration levels among VCs bring a higher supply of VC funds.

Finally, we used the pooled internal rate of return (*IRRpool*) as an equilibrium mechanism and the results suggest that the VC demand curve is downward sloping, and that the VC supply curve is vertical (perfectly inelastic).

The results make contributions at different levels, to the literature, practitioners and politicians. The findings make an important contribution to the literature on entrepreneurial finance, especially concerning VC. Firstly, they prove that the level of VC concentration is a determinant of VC supply, lower concentration bringing a greater supply of funds. Secondly, through simultaneous equation models, we help clarify the impact of some determinants (e.g., GDP) on VC activity. And finally, also for the first time, a measure of entrepreneurial activity was used that clearly distinguishes individuals who become

entrepreneurs because they found an opportunity from those who become entrepreneurs by necessity (the Opportunity-TEA).

A higher level of competition among VCs makes them specialize in terms of the type of investment they make, the life cycle of the investment or even from the geographical point of view (such as Christensen (2007) observed). VCs, as financial intermediaries, need to raise funds, and to do so, need to have a good reputation in the market. This has made them develop strategies that include specialization, to increase their reputation with fund providers, or even with entrepreneurs seeking financing.

Our results lead us to conclude that, from a theoretical point of view, it is competence-based theory that justifies the results obtained with the concentration level, taking into account resource-based theory or even traditional financial theory. According to resource-based theory and using an example given by Freiling (2004, 29): " . . . The resource-based view suggests that a firm A is more successful than firm B if A controls more effective and/or efficient resources than B (Barney 1991; Hunt 2000) . . . ". However, from competence-based theory " . . . A can only be more successful than B if A is in a position to make use of the available resources more effectively and/or efficiently than B . . . " (Freiling 2004, 29; Christensen 2007). Finally, according to traditional financial theory, the correct response by VCs to greater competition should be the diversification of investment (to spread risk).

For practitioners, VCs can conclude from this study that they should seek to invest in markets where: concentration levels among VCs are lower; there are good expectations for economic growth; stock markets have depth and are liquid; there are exit mechanisms that allow them to achieve good profitability (through trade sales and IPO); there are higher levels of business R&D compared to public R&D, so where there are technological opportunities; and, there is an appropriate fiscal and legal environment. From the point of view of the institutions back-funding VCs, they need to recognize that VCs need to compete and to specialize (pursue different investment strategies) in order to achieve success and thus improve their reputation.

From the point of view of politicians, if they want to stimulate the demand side of venture capital markets, they should: think about how to improve R&D investments made by entrepreneurs; develop a stable and appropriate fiscal and legal environment; moreover, thinking about the level of financial literacy in their countries, potential entrepreneurs are sometimes unaware of the sources of funding best suited to their business. On the other hand, if they want to stimulate the supply side of the VC market, there should be some degree of flexibility in policy instruments, in particular as regards eligibility criteria for subsidies and other supporting financial instruments that can be used by VCs to finance innovative business. Of course, a stable and appropriate fiscal and legal environment is also important.

Looking at more experienced VC markets, such as the US or even the UK, a sustainable VC market also needs public sponsored VC programs, and these need to work with a 25-year planning horizon (Doran and Bannock 2000; Christensen 2007).

This work is not without limitations. One of the difficulties of the VC market is to find a measure of the return. Although we used pooled internal rate of return, other equilibrium mechanisms should be tested. In addition, it would be relevant to study and identify conditions that would reduce the VC market concentration, and consequently develop VC activity (e.g., government intervention by creating mechanisms to reduce

concentration in the VC market). This work explores only the direct effects, so it would be interesting to have different data and apply different econometric models to explore the indirect effects. Finally, it would be important to be able to update the entire database in order to verify the results obtained in this work and also to study the impact of crises such as the 2009 financial crisis and the more recent COVID-19 pandemic.

Notes

1. Table A4 presents the correlation matrix to assess possible multicollinearity problems. Although some of the coefficients are significant, we test for multicollinearity risks by performing variance inflation factor (VIF) analyses. The highest VIF value is 3.18 which means we have no problems of multicollinearity in our analysis.
2. We begin by applying the equilibrium models in the reduced form to our database, with a view to validating the final model as well as measuring consistency, robustness, and adjustment to the literature. The results obtained were satisfactory and similar to those presented with the simultaneous equation method, so we opt not to include them.

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Appendix 1

Table A1. Potential VC determinants.

Potential Determinants	Demand	Supply
Pooled Internal rate of return (IRRpool)	-	+
HHI based on country investment (HHI)		-
Real GDP annual growth rate (GDPgr)	+	+
Market capitalization growth (MCgr)	+	a
Stock market capitalization (SMC)		+
Long term interest rate (IR)	a	-
Unemployment rate (UR)	a	
Annual trade sales divestment (Tsale)	+	+
Annual IPO	+	+
Annual write-offs	-	-
Public R&D capital stock (PRD)	+	+
Business R&D capital stock (BRD)	+	+
Opportunity-TEA (OTEA)	+	
Personal income tax rate (Pitx)	+	
EVCA tax and legal index (EVCAindex)		+

a = ambiguous.

Table A2. Description and sources of the variables.

Variable	Description	Sources	Authors who used
Dependent Variable			
Venture capital Investment (VC)	Professional equity co-invested with the entrepreneur to fund an early-stage (seed and start-up) or later stage venture. Offsetting the high risk the investor takes is the expectation of higher than average return on the investment. Venture capital is a subset of private equity. These amounts are divided by country-year GDP values.	Venture Capital Association (Invest Europe) Yearbooks	Jeng and Wells (2000), Schertler (2003), Romain and de La Potterie (2004), Parris (2007), Félix, Pires, and Gulamhussen (2007, 2013), Fuss and Schweizer (2009), Armour and Cumming (2006)
Independent Variable (exogenous)			
HHI based on country investment (HHI)	This index reveals the level of concentration among VC firms that have invested in a country. A higher value of HHI indicates higher concentration and thus lower level of competition among venture capitalists located in a country.	Thomson Financial's VentureXpert database	Christensen (2007), Li and Mahoney (2011)
Independent Control Variables (exogenous)			

(*Continued*)

Table A2. (Continued).

Variable	Description	Sources	Authors who used
Real GDP annual growth rate (GDPgr)	The country specific real GDP growth from the prior year to the current year.	Database AMECO from Eurostat	Gompers and Lerner (1998a), Jeng and Wells (2000), Marti and Balboa (2001), Romain and de La Potterie (2004), Armour and Cumming (2006), Félix, Pires, and Gulamhussen (2007), Félix, Pires, and Gulamhussen (2013); Schertler (2007) and Bonini and Aktuccar (2009)
Market capitalization growth (MCgr)	The country specific market capitalization growth from the prior year to the current year	World Bank database	Jeng and Wells (2000) and Félix, Pires, and Gulamhussen (2007, 2013)
Stock market capitalization of listed companies (SMC)	Market capitalization is the share price times the number of shares outstanding. Listed domestic companies are the domestically incorporated companies listed on the country's stock exchanges at the end of the year. Listed companies do not include investment companies, mutual funds, or other collective investment vehicles. These amounts are divided by country-year GDP values.	World Bank database	Schertler (2003), Clarysse, Knockaert, and Wright (2009), Kelly (2010)
Long term interest rate (IR)	Long-term lending real interest rate is adjusted for inflation as measured by the GDP deflator.		Romain and de La Potterie (2004), Schertler (2007), Félix, Pires, and Gulamhussen (2007) and Félix, Pires, and Gulamhussen (2013), and Fuss and Schweizer (2009)
Unemployment rate (UR)	The unemployment rate is the number of people unemployed as a percentage of the labor force. The labor force is the total number of people employed and unemployed.	Database AMECO from Eurostat	Félix, Pires, and Gulamhussen (2007), Félix, Pires, and Gulamhussen (2013), Clarysse, Knockaert, and Wright (2009) and Kelly (2010)
Annual IPO divestment (IPO)	The sale or distribution of a company's shares to the public for the first time. These amounts are divided by country-year GDP values.	Venture Capital Association (Invest Europe) Yearbooks	Gompers and Lerner (1998a), Jeng and Wells (2000), Félix, Pires, and Gulamhussen (2007), Fuss and Schweizer (2009), and Bonini and Aktuccar (2009)
Annual trade sales divestment (Tsale)	The sale of company shares to industrial investors. These amounts are divided by country-year GDP values.		Félix, Pires, and Gulamhussen (2007)
Annual write-offs divestment (WO)	The write-down of a portfolio company's value to zero. The value of the investment is eliminated and the return to investors is zero or negative. These amounts are divided by country-year GDP values.		Félix, Pires, and Gulamhussen (2007) and Félix, Pires, and Gulamhussen (2013)

(*Continued*)

Table A2. (Continued).

Variable	Description	Sources	Authors who used
Public R&D capital stock (PRD)	The public R&D capital stock (measured at the end of each period) is computed by a perpetual inventory method with a constant rate of depreciation (d = 0.15). The values of R&D public expenditure are available for each country from 1981 onward from OECD Basic Science and Technology Statistics database. The first year used in estimation (1992) is calculated by summing up the expenditure from 1981 to 1992 appropriately valued at 1992 prices. These amounts are divided by country-year GDP values.	Database AMECO from Eurostat	
Business R&D capital stock (BRD)	The business R&D capital stock (measured at the end of each period) is computed by a perpetual inventory method with a constant rate of depreciation (d = 0.15). The values of R&D business expenditure are available for each country from 1981 onward from OECD Basic Science and Technology Statistics database. The first year used in estimation (1992) is calculated by summing up the expenditure from 1981 to 1992 appropriately valued at 1992 prices. These amounts are divided by country-year GDP values.		Bonini and Aktuccar (2009)
Opportunity-TEA (OTEA)	Percentage of those involved in TEA who (i) claim to be driven by opportunity as opposed to finding no other option for work; and (ii) who indicate the main driver for being involved in this opportunity is being independent or increasing their income, rather than just maintaining their income. TEA is the percentage of 18–64 population who are either a nascent entrepreneur or owner-manager of a new business.	Global Entrepreneurship Monitor (GEM)	
Personal income tax rate (PItx)	The personal higher marginal income tax rate in each country – year.	Worldwide corporate tax guide and https://www.cesifo-group.de	Gordon (1998), Rin, Nicodano, and Sembenelli (2006) and Cullen and Gordon (2007)

(*Continued*)

Table A2. (Continued).

Variable	Description	Sources	Authors who used
EVCA tax and legal index (EVCAindex)	This index is based on seven criteria split in 30 variables that are determinant for the good functioning of the private equity and venture capital ecosystem. This index ranges from 1 to 3, with 1 indicating a more favorable legal and tax environment for the development of private equity and venture capital.	Venture Capital Association (Invest Europe) Yearbooks	Armour and Cumming (2006) and Kelly (2010)
HHI based on country investment (HHI)	This index reveals the level of concentration among VC firms that have invested in a country. A higher value of HHI indicates higher concentration and thus lower level of competition among venture capitalists located in a country.	Thomson Financial's VentureXpert database	Hong, Serfes, and Thiele (2020)
Endogenous variable			
Pooled Internal rate of return (IRRpool)	The IRR is the interim net return earned by investors (Limited Partners) from the fund from inception to a stated date. The Pooled IRR is the IRR obtained by taking cash flows from inception together with the residual value for each fund and aggregating them in to a pool as if they were a single pool.	Thomson Financial's VentureXpert database	

Table A3. Mean and standard deviation of each variable and Correlation Matrix of the natural logarithm of each variable.

	Mean	St. Dev.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) VC	0.081	0.07	1															
(2) HHI	0.265	0.308	−.530**	1														
(3) GDPgr	0.022	0.028	.128*	0.039	1													
(4) MCgr	0.142	0.321	0.012	0.038	0.085	1												
(5) SMC	74.244	57.319	.563**	.130*	0.021	−.515**	1											
(6) IR	0.033	0.018	−.213**	0.047	.163**	−.236**	.361**	1										
(7) UR	0.073	0.034	−0.06	0.074	.195**	−.166**	.298**	.171**	1									
(8) Tsale	0.028	0.034	.470**	0.022	0.018	.434**	−.211**	0.036	−.420**	1								
(89 IPO	0.011	0.019	.461**	−0.014	−0.036	.469**	−0.11	−0.083	.439**	−.430**	1							
(10) WO	0.010	0.016	.286**	−0.003	−0.03	.122*	−0.036	0.036	.159**	.361**	−.231**	1						
(11) PRD	0.003	0.001	−0.009	−0.059	0.081	−.121*	.154*	.213**	.176**	.153*	.190**	−.203**	1					
(12) BRD	0.004	0.002	.134*	−0.027	0.033	.283**	0.03	0.106	.177**	.162**	.138*	.664**	−.397**	1				
(13) OTEA	0.033	0.014	0.067	.128*	−0.061	−0.06	−.147*	−.267**	−.135*	−.152*	−.126*	−.471**	−.522**	.236**	1			
(14) Pitx	0.395	0.136	−0.078	0.073	0.062	−.321**	0.079	.402**	.156*	−0.069	0.068	.461**	.135*	−.376**	−0.092	1		
(15) EVCAindex	1.857	0.343	−.279**	−0.038	0.008	−.400**	.199**	0.043	−.468**	−.164**	−0.11	0.09	−0.063	−.123*	−0.026	.286**	1	
(16) IRRpool	6.675	5.8251	.245**	.149*	0	.211**	.173**	0.053	.266**	.240**	.199**	.367**	.414**	−.268**	0.057	−0.013	−.147*	1

Note: * Correlation is significant at the 0.05 level.
**Correlation is significant at the 0.01 level.

Table A4. Two stage least squares (2SLS).

Potential determinants	Demand	Demand	Demand	Supply	Supply
	(1)	(2)	(3)	(4)	(5)
IRRpool	−0.403	−0.541	−0.572	−0.0817	−1.227
	(−2.83) [a]	(−2.69) [a]	(−2.49) [b]	(−1.25)	(−1.43)
HHI	X	X	X	−0.315	−0.298
				(−4.43) [a]	(−3.72) [a]
GDPgr	0.586	0.73	0.763	0.176	0.223
	(3.08) [a]	(2.83) [a]	(2.66) [a]	(1.81) [c]	(1.87) [c]
MCgr	−0.039	−0.053	−0.556	−0.017	−0.023
	(−0.41)	(−0.44)	(−0.44)	(−0.37)	(−0.44)
SMC	X	X		0.256	0.227
				(1.68) [c]	−1.34
IR	0.176	0.268	0.289	0.047	0.518
	−0.87	−1.03	−1.03	−0.61	−0.54
UR	−1.092	−1.448	−1.528	X	X
	(−1.77) [c]	(−1.77) [c]	(−1.72) [c]		
TSale	0.188	0.213	0.219	0.116	0.136
	(1.65) [c]	−0.47	−1.43	(1.89) [c]	(1.91) [c]
IPO	0.034	0.306	0.296	0.019	0.019
	(1.69) [c]	−1.18	−1.09	(1.74) [c]	(1.63) [c]
WO	0.032	0.031	0.03	0.274	0.028
	−1.01	−0.75	−0.71	(1.79) [c]	(1.68) [c]
PRD	−2.223	−2.372	−2.406	−1.038	−1.232
	(−2.21) [b]	(−1.85) [c]	(−1.78) [c]	(−1.72) [c]	(−1.77) [c]
BRD	2.918	3.355	3.453	1.155	1.406
	(3.07) [a]	(2.72) [a]	(2.6) [a]	(1.93) [c]	(1.97) [b]
OTEA	−0.088	−0.232	−0.264	X	X
	(−0.14)	(−0.28)	(−0.30)		
Pitx	1.229	1.553	1.627	X	
	(2.00) [b]	(1.93) [c]	(1.87) [c]		
EVCAindex	X			1.115	1.293
				(1.96) [b]	(1.98) [b]
Const	2.934	4.477	4.826	−2.89	−2.186
	−0.7	−0.83	−0.84	(−0.117)	(−1.01)
R − squared	...	...	...	0.540	0.452
Wald test	81.75 [a]	53.14 [a]	47.89 [a]	366.55 [a]	308.40 [a]
Wu-Hausman test	37.110 [a]	52.000 [a]	53.185 [a]	2.751 [c]	3.480[b]
Sargan test	4.220	0.129		1.783	0.755

Note: In parentheses we present the values of the z-statistics for each variable. The tests statistics are significant at the following levels: a − 1%; b − 5%; c − 10%.

Simultaneous equation estimates of the demand and supply for VC. t-statistics are presented below the coefficients in (). Natural logarithm of each variable. Endogenous variable: IRRpool. With country dummies. X = instrumental variables.

Table A5. Econometric results for analysis of omitted variable bias.

	Dependent variable - VC	
Potential determinants	(1)	(2)
IRRpool		0.008
		(1.38)
HHI	−0.161	−0.166
	(−5.83) [a]	(−5.97) [a]
GDPgr	0.042	0.033
	(1.63) [c]	(1.25)
MCgr	−0.006	−0.005
	(−0.29)	(−0.28)
SMC	0.130	0.135
	(2.16) [b]	(2.24) [b]
IR	0.005	0.002
	(0.15)	(0.06)
UR	0.099	0.121
	(0.98)	(1.19)
Tsale	0.038	0.035
	(1.68) [c]	(1.57)
IPO	0.007	0.007
	(1.61) [c]	(1.58)
WO	0.014	0.014
	(2.13) [b]	(2.15) [b]
PRD	−0.253	−0.219
	(−1.15)	(−0.99)
BRD	0.265	0.217
	(1.42)	(1.15)
OTEA	0.217	0.231
	(1.68) [c]	(1.79) [c]
Pitx	0.010	−0.008
	(0.09)	(−0.07)
EVCAindex	0.273	0.247
	(1.26)	(1.14)
Const	−0.806	−0.842
	(−0.89)	(−0.93)
R – squared	0.449	0.454
Hausman test	49.01 [a]	50.97[a]
F Test for Fixed Effects	4.98 [a]	4.62[a]
F test	14.04 [a]	13.28[a]
Oster's delta		7.94

Note: In parentheses we present the values of the t-statistics for each variable. The test statistics are significant at the following levels: a – 1%; b – 5%; c – 10%.