Corporate Venture Capital Syndication and Relationships in Syndication Networks

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Abstract:

In the industry of venture capital, the majority of investments in startups are realized in the form of syndication by venture capitalists (VCs), which diversify thus their risk and maximize their profits. Corporations also invest in startups with VCs, but often for different reasons. They rather seek to acquire information on the marketable innovations or new technologies. Their growing weight (17% of total investment in venture capital in 2015, against 8% in 2010) puts the question of the determinants of their investments. So, we investigate how their relations with VCs and their relationships in syndication networks influence their decisions of investment.

Using data of corporate venture capital (CVC) investments by US corporations between 2001 and 2013, we analyze their expenditure of CVC following their position in syndication networks, and their financial resources. The GMM models used show that the annual amount of CVC expenditures of these companies depends on the number of their relations of co-financing and their cash-flows of the previous year, and also their preceding investments. On the other hand, their previous centrality in the networks of syndication is not significant, contrary to the social network theory, which stipulates that prior central positions in syndication networks significantly explain future network positions of corporate venture capitalists.

Key words: venture capital, corporate venture capital, network, financing, syndication, start-up

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1. INTRODUCTION

The acceleration of the technological changes is accompanied by new organizational forms allowing a fast adaptation to changing environments (Baldwin and Clark, 2000). In particular, the new environment of high technology markets undermines the interests traditionally associated with internal R&D (Schumpeter, 1950). Indeed, on the one hand, investment in R&D appears increasingly risky (Kothari, et al. 2002). On the other hand, the income horizon from holding patents on innovation is reduced (Cohen et al., 2000). It follows that the massive investment in internal R&D cannot, by itself, ensure the sustainability of high-tech firms. They are also looking outside their internal R&D laboratories, the means to ensure their survival. Therefore, the nature of the means employed by high-tech firms' managers to sustainably generate a sufficient level of cash flow to meet the requirements of fund providers are questioned (Henderson and Clark, 1990; Dougherty and Corse, 1995; Dushnitsky, 2006).

Among these means, the corporate venturing (CVC) defined as direct minority equity investments made by established companies in privately-held entrepreneurial ventures (Gompers and Lerner, 1998) is of first interest. Indeed, Brown et al. (2009) attribute 75% of the technology boom of the 1990s to the massive growth of the supply of finance to young innovative companies during this period. Furthermore, Kortum and Lerner (2000) suggest that the venture capital, although it represented on average less than 3% of firms' R&D expenses in the period 1983 to 1992, was responsible for 10% of US industrial innovations during this decade. Constrained by their financial resources, industrial firms are minor players in the venture capital industry dominated by specialized financial institutions (Dushnitsky 2006). This leads the former to syndicated 90% of their CVC investments with the latter (Basu et al., 2009) in order to acquire diversified information about the next marketable innovations. The VC investments' syndication leads to the constitution of an investor network. This means that different types of investors are dependent on resources controlled by others and the pooling of resources can be beneficial to all (Weil and Durieux, 2000).

However and from the industrial firms' perspective, the current conditions of the venture capital networks' efficiency are largely unexplored. First, Basu et al. (2009) stress that research on CVC is limited and has only recently attracted renewed interest. Second CVC stud-

ies include data from the 1990's period that generally constitutes more than 70% of the sample's information. However, as the vast majority of industrial firms embedded in VC networks during the 1990's now withdrew it seems hard to pretend that their CVC investments were efficient. Third, network theory suggests that a central position is the best way to capture information from other network members. As CVC only counts for only 17% of VC investments, this "best strategy" may not be reachable for all industrial firms. Therefore the existence of a second best strategy adopted by the industrial firms is questioned. Finally the literature indicates that Venture Capitalists do not need the industrial firms' financial resources to finance innovative startups. It follows that the nature of the resources made available by industrial firms to the other network members is questioned. To the best of our knowledge, Keil et al. (2010) are the first to give some answers to this question and their seminal works deserve to be deepened. In particular, the two relationships between the amount invested by corporate in CVC and their position in the syndication network, on one hand, and between the position in the networks of syndication and the resources of the CVC parent, on the other hand, have to be confirmed.

From sample of 284 industrial firms which made at least one syndicated CV investment with venture capital firms during the 2001-2013 period this article aims to study the relational strategies employed by industrial firms to capture information from VC network. This leads us to question the nature of the resources these firms made available to the other network members in order to sustain their position in the VC network.

The rest of this paper is organized as follows. Section 1 reviews the literature and current theoretical perspectives to explain the profile and the objectives of industrial firms engaged in CVC activities. Section 2 details the interests that rely on the industrial firm's position in the VC network. Section 3 presents the study's methodology and section 4 shows the empirical results. Section 5 concludes.

2. CHARACTERISTICS AND OBJECTIVES OF CORPORATE VENTURE CAPITAL

2.1 Definition of corporate venture capital and profile

In strategy, two types of technological alliances exist: cooperation agreements and capital participation. If the first type is based on a short or medium-term partnership, aiming at sharing

certain strategic resources in particular in terms of R&D, the second type of strategic alliance leads to an exchange of capital and thus to strong commitments from each partner.

Along with joint-ventures and partial mergers, corporate venture capital (CVC) today has became one of the most widespread forms of financing for new innovating firms. In fact, CVC is only another form of venture capital. The concept is not recent and first made an appearance at the end of the thirties in the United States. It developed gradually to become a branch of finance specialized in funding innovative SMEs with strong growth potential.

The role of "corporate venture capital" funds, also named "industrial venture capital funds", is for a parent company to contribute capital equity complemented by industrial input to an innovative startup through an investment fund dedicated to industrial innovation. This type of fund excludes any entity with a purely financial company as lead investor. The main difference between corporate venture capital and venture capital is the nature of the utility of fund partners. Contrary to a traditional venture capital firm which seldom intervenes in the day-to-day running or decision making process of the firm it finances, CVC goes much further than simple leveraging. The incentive for industrial groups to get involved in CVC can be summarized according to the five following points: (1) Technological interest: by investing in highly innovative firms in the same line of business, industrial groups can track innovations closely while keeping a lid on its R&D expenditure. In this way corporations can guard against these firms making technological breakthroughs by signing agreements for developing joint projects, license transfer or the acquisition of the firm at a later date (integrating the target company into the group) as from the first input of funds, (2) adding value to in-house R&D: by supporting the creation of a startup by spinoff, corporations develop their patent portfolio, the majority of which are often unexploited, via licensing agreements, (3) market tracking and the experience effect: financing startups in new markets provides investors with information on customer behavior vis-à-vis new products/services which could be used to develop new products/services inside the group,

Thus, industrial firms with a low propensity to innovate have little need to invest in CVC.

Hypothesis 1. The industrial firm's propensity to innovate be positively associated with the CVC investments amount.

* Implementing new practice: the startups in which the groups invest can be used as a laboratory to test new practices of external management (vis-à-vis customers or suppliers) or inter-

nal (between employees, between management and staff) which could be adopted by the group if successful,

* Financial interest: last but not least there is the financial aspect. As for other venture capital investments, the corporations hope to have made a capital gain on their investment at the time of exit or a return through dividend payments.

In this context, there are two ways of viewing the concept of CVC; as external risk taking for the firm or as an alternative source of financing innovative startups (Gompers & Lerner, 2000). These two conceptions of CVC are not contradictory. Quite the reverse is true. They show common interests shared through an organizational mode which ensures the outsourcing of risk while enabling the financing and control of innovative projects. This is why CVC is often initially defined (Muzyka et al., 1996) as an input of capital equity and technical or strategic expertise to startup entrepreneurs. This highlights the relationship of dependence that the startup has from the parent company. This relationship of dependence is conditional on the control exerted by the parent company on the investment fund and one can thus distinguish two categories of CVC: (1) Semi-captive funds are created and capitalized by a large company which keeps control of it. The funds may be open to other industrial partners. The strategic objective of these funds is to invest primarily in projects close to the core activity of the original investors. This is the case for Innovacom, Emertec, Chrysalead. (2) Captive funds are wholly owned by the parent company and their goal is to serve the strategic and financial interests of the latter. This is the case for Unilever Technology Venture, France Telecom Technologies Investments, Intel Capital.

Thus, contrary to management firms specialized in venture capital, CVC has a strategic approach which is primarily industrial. These funds seek to invest in projects which have synergies with the corporation's own businesses.

However, the organizational changes resulting from the implementation of Corporate Venture Capital programs are not always positive, hence the many detractors. The drawbacks include:

Firstly, preserving integrity towards projects which are in competition with those of the parent company. Secondly, yielding to the economic climate and the strategic choices of their chief executives. The capital often comes from the surplus liquidity of the parent company. Their existence is therefore called into question during an economic downturn. There are no lack of examples; Innovacom (France Telecom) and Viventures (Vivendi) are today independent. Valéo Venture was closed down by the new CEO who considered that the program was of

'little strategic interest', whereas Air Liquide Ventures was taken over by Alto Invest for the same reasons. In sum, we expect that surplus liquidity of the parent company drives the amount of CVC investments.

Hypothesis 2. Industrial firm's cash-flow will be positively associated with CV investments.

To be successful, the financial intermediation in CVC should restore the dominant role of financial activism by including the processual dimension of investment and investment withdrawal. By investing in projects, the CVC acquires information whose value is maximized if the transaction costs of project identification, selection, investment, follow-on support and withdrawal are lower than those which would be generated by direct investments. Consequently, the intermediation in CVC is only relevant to new ventures whose specificity is not only to be innovating, but also to offer something outside the firm's expertise. In other words, the CVC justifies its role if: (1) financial undertakings are targeted at innovative startups whose information is not transparent (firms with asymmetric information), (2) the need for a device to indicate the quality of targeted projects is vital to avoid multiplying direct investments in innovative projects a large proportion of which could turn out to be unsuccessful or not strategic. If the identification-selection-investment process is efficient, then the CVC investments will be renewed year after year.

Hypothesis 3. Prior CVC investments will be positively associated with the future CVC investments.

2.2. Objectives of CVC

While the goal of an independent VC is looking for performance, a CVC fund must balance strategic objectives from its parent company and financial goals. These objectives can be conflicting and create agency conflicts between financed firms and the CVC fund. It is therefore necessary to analyze the goals of CVC funds in order to understand their influence on value creation of companies they fund. Generally, a CVC fund has a strategic mission to improve competitiveness and consequently the turnover of its parent company. As for their mode of intervention, almost all funds privilege direct investments (90% of funds), and 60% of CVC funds made limited partners investment (NVCA, 2010). Lantz et al. (2011) show that almost 70% of CVC investors have a combination of strategic and financial objectives: 15% invest only for strategic value and 16% only for financial return. Moreover, even if 50% invest pri-

marily for strategic value, financial return is a requirement. On the same way, for the 19% of CVC funds, which invest primarily for financial return, look for synergies with the target. Following the results presented in table n°4, the main strategic reasons cited by the managers of CVC funds are mainly the access to new markets (92%) and the development of products (88%) or technologies (83%). These results are consistent with previous studies which identify three principal strategic motives for this type of investment: gain "window" on emerging technologies (Dushnitsky & Lenox, 2005), facilitate development of firms offering complementary products or services (Chesbrough, 2000), and identify and monitor potential acquisition targets (Maula and Murray, 2001). Therefore industrial firms should maintain relationships with the largest number of venture capitalists in order to enlarge sustainably their window on emerging technology and build a wider ecosystem around their own products.

Hypothesis 4. Prior number of relationships in the VC network will be positively associated with the amount of the future CVC investments.

For big firms (BF), carrying out this type of investment permits them:

(1) to accelerate their process of training: CVC avoid big costs of R&D programs by multiplying and diversifying projects and investments. The CVC supports investments in startups (and financial risk involved) while its parent office (BF) can benefit from the innovations accomplished by startups, (2) to increase the effectiveness of technological watch. The objective is to identify the emerging markets as well as uses of customers and potential applications (Maruca 1999), to create a complete system of offer with some partner customers, and to detect relational or processual innovations which, if they prove to be effective, will be adopted by the parent company. These techniques make it possible to precede innovation for on the one hand, not to be outdistanced on markets in the midst of technological changes and, on the other hand, to avoid developing similar in-house projects that are perfectly carried out outside (this resulting in clearly reducing in-house human costs and increasing the R&D on the key activities of the parent company, (3) to have a new means of action. Indeed, the CVC offers the BF the possibility of managing the innovation in "acting to understand". The objective is to act first, to invest in a startup, to launch a product or service by keeping the necessary flexibility to go back once the BF tests the utility of innovation. It is the opposing view to the traditional R&D approach.

3. NETWORK POSITION OF CVC IN SYNDICATION

3.1. Syndication and social networks

The syndication is a usual practice in the industry of venture capital (VC), which consists in sharing, between professional investors (funds, banks, etc.), the financing of a company for a financing round (Brander et al., 2002). Beyond the strict contribution in capital, venture capitalists (VClists) are generally known for their active management of the companies which they finance and for their capacity to add them value. This phenomenon generated a theoretical and empirical literature aiming to explain the behavior of syndication and to analyze their impact on the performances of the firms, which have been financed by this means.

We distinguish two types of results concerning the intensity and the motivations of syndication. With regard to the intensity, it would seem that American VClists adopts this practice more than Europeans VClists. That concerned in 2001 only 30% of VC investments in Europe against 60% in the USA (Wright and Lockett, 2003). Moreover, Dushnitsky (2006) or Basu et al. (2011) stress that 90% of the investments of corporate venture capital (CVC) are syndicated. This percentage falls to 66% for VC (Sorenson and Stuart 2001). This disparity of behavior would come mainly from the greatest specialization of American VClists according to Manigart et al. (2002). Other studies tie the percentage of syndication at the development stage of the project. In particular, Deli and Santhanakrishnan (2010) find that syndication is more likely for firms in the earliest stage of development (when growth opportunities and risks are greater) and firms in the last stage of development as private firms (when human capital investments and needs of financial capital are largest). Thus, the intensity of syndication would be related to the strategic choice of VClists and financed firms.

On the level of their motivations to be syndicated, VClists arbitrate between the benefits of syndication and the costs implied by this strategy, in particular the agency costs (Wright and Lockett, 2003). The literature in this field identified four reasons for syndication which are not necessary independent each other (Lehmann, 2006): (1) the diversification of financial risks. By splitting their investments, VClists can invest in a greater number of companies in the objective to diversify their risks, while hoping to reach the same total return. In particular, Lockett and Wright (2003) demonstrate empirically that, more the financial risk of start-up is high and more VClists tend to syndicate, (2) the selection of projects. This selection is carried out ex-ante and ex-post. Lerner (1994) considers that in the presence of uncertainty on a project, a process of evaluation by several investors makes it possible to improve the ex-ante selection. While Huang and Xu (2003) show that the purely financial syndication constitutes an

engagement to refinance ex post only the best projects. The entrepreneurs, being conscious that the slightly profitable projects will not find refinancing and wanting to avoid liquidation, will not present these projects to investors for a new financing round. The effectiveness of this type of strategy is strongly related to this self-censorship of entrepreneurs. (3) the business flow. Manigart et al. (2006) highlight that "it is important for VClists to have access as much as possible to a great number of investment opportunities (start-ups) in order to really select the best". By syndicating their own investments, VClists hope to create reciprocity with other investors (Lockett and Wright, 2003). (3) the creation of value. Lehmann (2006) stresses that a leader investor of a company syndicates to attract expertise when he believes that the implication of other investors could "add value" to this firm.

From a theoretical point of view, the first reason concerns a purely financial approach, while the three others are based on the resource dependence theory. This theory explains how firms' behavior is shaped by access to their most crucial resources, those resources one which to their business activities depends (Pfeffer and Salancik 1978). It suggests that has firm' s survival and adaptability are determined in share by its access to scarce resources, including information obtained through its relationships with all its stakeholders.

With respect to the impact of syndication on the performance of financed firms, the majority of the empirical studies undertaken in North America show a positive effect (Brander et al., 2002). Giot and Schwienbacher (2007) also find that, the size of syndication has a positive impact on the success probability of firms. However, some studies contest these results because of the free-rider problem – some investors can reduce their level of efforts to rest on the other co-investors of the syndication (Dimov and De Clercq, 2006), difficulties of coordination in large syndications (Wright and Lockett, 2003), or conflicts of interests between the members of the syndication (Stévenot-Guery, 2007).

Lastly, the networks of syndication have also an intangible impact. They allow the creation of social capital which profits to the financed firms and all co-investors. Networks are generally understood as, and predicated on, creating and representing social capital (Coleman, 1988), which in turn is said to support knowledge transfer and learning processes both on an individual and on an organizational level, and to promote innovation (Moran, 2005).

In the case of VC, Manigart et al. (2004) show that propensity to syndicate investments is explained by the will of access for investors to intangible resources. Among those, the access of industrial companies to knowledge held by financial firms of VC represents an important is-

sue because they provide more than 80% of financing needs of innovative start-ups. For Wirtz (2006), the contact frequency of these VClists with start-ups allows a reconciliation of cognitive models of each other. In addition, Desbrières (2011) stresses that the small degree of sectoral diversification of the VClists" investments is a big factor of knowledge creation.

The VClists are thus in the center of the creative process of knowledge. Consequently, the establishment of relationships with these VClists represents an important cognitive stake for industrial companies. In fact, Birkinshaw and Hill (2005) note that industrial companies which co-invest with financial firms of VC associate a greater strategic value to their expenditure of CVC than industrial companies which finance start-ups alone. Chesbrough (2006) announces that these relations help industrial companies to manage their internal R&D effectively. Finally, Hochberg et al. (2007) show that industrial companies are confronted with a problem of innovating project selection. Thus, the majority of industrial companies chooses to intervene tardily in the financing of start-ups and generally invited by financial firms of VC. Knowledge that industrial companies draw from these invitations constitutes a private benefit which leads them to pay a premium to take part in the capital of start-ups (Gompers and Lerner, 2000). In this perspective, Maula et al. (2005) also highlighted for CVC syndication that social interaction is strongly positively related to the level of knowledge acquisition from the investor relationships. The syndication of CVC investments appears to be strongly link to the need of knowledge acquisition from industrial firms and therefore to their propensity to innovate. However the premium paid to VClists to acquire knowledge demand sustainable financial resources to enter the syndication. This leads us to the two following hypotheses :

H 5. Industrial firm's R&D expenditures will be positively associated with its number of relationships in the VC networks.

H 6. Industrial firm's cash-flow will be positively associated with its number of relationships in the VC network.

3.2 Centrality in network and resources off CVC

Several studies showed that syndication is a very widespread strategy among the corporate venture capitalists (CVClists), which has multiple motivations (Manigart et al., 2006). The underlying issue is thus to know if the position of investors in the syndication network, and more particularly their centrality, has an impact on the realization of their objectives.

As the VClists and CVClists do not pursue the same goals, the firsts having only one objective of maximization of the firm value in which they invest, contrary to the seconds, the question of the centrality for these two types of investors must be apprehended separately, whereas we observe a certain amalgam in the literature.

Some authors defend the thesis that the VClists and CVClists look for achieve a strong central position in syndication networks in order to get more performance. If this argument seems logical for VClists (Abel and Nisar, 2007; Hochbert et al., 2007; Sorenson and Stuart, 2001), which seeks to maximize the companies value, it is largely criticizable for the CVClists taking into account the diversity of their motivations of investment.

In particular, Hill et al. (2009) show that centrality in VC networks exerted has positive and significant impact one financial performance, goal year insignificant impact one strategic performance.

According to network theory, the centrality in has syndication network is regarded ace the best measure for average overall access to information available in this network (Freeman, 1999; Noyes et al., 2014).

In fact, more the investors occupy a central position in the syndication network, more they accumulate information (on the start-ups in which they invested, but also on all the start-ups financed by VC, technologies which these firm use, the industry sector of start-ups and their markets,…) and reputation. If this strategy is effective, then the industrial companies occupying a central place in the network will try to maintain their position in the network.

Hypothesis 7. Prior industrial firms centrality in the VC network will be positively associated with the future amount of CVC investments.

These investors, having a central position, have a faster access to high quality information on the opportunities of investment (Bygrave, 1987). That increases their capacity to identify and attract start-ups with a strong potential (Sorenson and Stuart, 2001).

Moreover, these investors because of their visibility and good reputation are attractive for start-ups by facilitating the access to other investors, and providing them some contacts or added value services (Hochberg et al., 2007). For their potential co-investors, they give a signal on the quality of the firms in which they invested, and they can provide an access in convenient time to valuable information which are very difficult to obtain (Dimov et al., 2012).

Thus, we can synthesis the objectives of these two categories of investors:

- For VClists : Centrality => better information => better identification of the potential firms = > better realization of their financial objectives, more return

- For CVClists : Centrality => better information => better realization of their financial and strategic objectives. From a theoretical view point, the resource dependency theory argues that firms are able to exploit new growth opportunities based on the resources they garner through their relationships (Pfeffer and Salancik, 1978).

The last question about centrality is to ask how investors can reach this central position.

Because of inertia effects, the current centrality depends on the previous centrality and the capacity to generate new investments. Central Firms occupying network positions are more likely to engage in CVC investment (Noyes et al., 2014).

The resources of the CVC parent can make it possible to reach a central position quickly. To our knowledge, only the study of Keil et al. (2010) exists in this field. They highlight a negative relation between the level of unique resources held by the CVC parent at one period and the centrality of its CVC subsidiary at the previous period. This result suggests that the central VC valorize the unique resources held by the CVC parent. Thus these resources can act like a substitute to the absence of central position of the CVC subsidiaries, and allow them to enter syndications which are generally inaccessible to peripherals investors. Thus, the resources of the CVC parent are a substitute to an unfavorable position in the syndication network.

By providing an improved understanding of VC syndication, they bring a new element to social network literature because most of researches on this topic consider *that networks are exogenous in that they are not caused by or correlated with unobserved attributes of the actors forming these networks* (Stuart & Sorenson, 2007).

These results also make it possible to better understand the mechanisms of accumulation of resources and substitution which are in the center of the relational view of strategic management. It conceptualizes the inter-organizational relationship of a firm as a relational resource difficult to build and which can bring much value for the company at its origin.

However, the methodology used by Keil et al. (2010) is strongly contestable. They take the turnover of the last year as a proxy to measure the next year available resources. But the capacities of investment of a firm depend on its cash-flows and its capacity of financing (by loan or capital). As the turnover is very partially correlated to the cash-flows, it is in fact a very bad indicator of the available resources of the firm to invest the next year. The question

of the relationship between the position in the networks of syndication and the resources of the CVC parent has to be confirmed.

In our study, we retain three different types of resources: access to product market (Rajan & Zingales, 1998), finance (cash-flow), and knowledge (R&D).

H 8. Industrial firm's net sales will be positively associated with its closeness centrality in the VC networks.

H 9. Industrial firm's cash-flow will be positively associated with its closeness centrality in the VC network.

H 10. Industrial firm's propensity to innovate will be positively associated with its closeness centrality in the VC network.

4. METHODS

4.1 Sample and Data

The data for our analysis come from the Securities Data Corporation (SDC) Venture Economics database and was complemented by accountable information concerning CVC firms thanks to Orbis (BVD). First SDC database is widely used for venture capital studies (Keil et al., 2010) and allows to identify the industrial firms that have corporate venture subsidiaries. However, the use of this database as well as the characteristics of the venture capital market impose geographical, sectoral and temporal limits. Indeed, on a side, if the study undertaken by Kaplan and al. (2002) concludes that the information deferred by the SDC database does not present important skews, these authors note that SDC focus on U.S. VC investments in direction of start-ups also domiciled in the United States. Consequently, we chose to focus our study on the U.S. industrial firms financing the start-ups located in the United States. On the other side, the VC activity concentrates on industries presenting the best technological development opportunities. Thus, 63% of the financing for which we have information relate to Information Technology[1] (IT) start-ups. As the computation of network positions require many data, we choose to focus our study on IT industry and select only the industrial firms financing the start-ups of this industry. Finally, the IT start-ups financing gave place to the swelling of a speculative bubble starting from second half of the 1990's. The bursting of this bubble in

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[1] Like Hochberg and Al (2007), we defined these sectors using SIC coding: Information technologies (357*, 367*, 48 **, 3663)

2001 led to the withdrawal of the investors attracted by short term financial profits. This led to significant changes in the relative positions of investors in the venture capital network. Because of the important fall of CV firm number and investments after the 2001 bursting bubble that shake off the VC investor networks, we chose to focus our study on the 2001-2013 period. At the end of this process we identified 284 industrial firms which made at least one syndicated CV investment with venture capital firms during the 2001-2013 period. Table 1 summarizes the industrial investor's profile of our sample.

Table 1. Industrial VC investors profile

Variables	Median	Mean	S.D.	Q1	Q3	Min	Max
Number of years firm invested during the 2001-2013 period	2	3.7	3.5	1	5	1	13
Firm seniority (year)	11	17	30.59	6	20	1	135
CV experience (year)	9	10	7.5	4.6	15	0	46
Number of rounds firm participated during its whole VC experience	11	43	124	4	30	1	1794

Table 1 shows that our sample consists of young industrial firms. The median firm of our sample has 11 years old and made its first VC investments 9 years ago. Moreover its activity as CV investor is low: during its whole CV experience the median firm only participated to 11 financing rounds, which is less than 2 rounds per CV experience's year and invested only 2 years between 2001 and 2013.

Second, we accessed to the accounting information concerning our sample firms thanks to Orbis (Bureau van Dijk) database. Orbis combines information from regulatory and other sources and delivers financial and accounting information about 170 million companies across the globe. OECD used this database that respond to the need for firm-level micro-data analysis of this institution (Pinto Ribeiro et al., 2010).

Dependent Variables

Ernst & Young regularly stresses the large annual variation of corporate venture investments. Thus, we decided to highlight some determinants of the industrial firms decision to invest in IT start-ups before focusing on explaining variables of the annual relationships of industrial firms in the VC investors networks.

Firm annual CV investment: From SDC data we compute the annual CV investment of each industrial firm of our sample for the period 2001-2014.

Annual number of co-investors: SDC allows us to compute the number of firms with whom each industrial firm invests each year. As the size of the investors network varies each year and so the possible number of relationships, we standardized this variable.

 Independent variables

Our independent variables are prior annual number of co-investors, prior annual closeness centrality, prior annual cash-flow, prior annual R&D expenses and prior annual net sales.

Prior annual number of co-investors: we operationalize a 1 year lagged to the variable used as dependant variable. The prior annual number of co-investors allows to take account of each industrial firm commitment in the syndication it is embedded in.

Closeness centrality: we used the closeness centrality to measure path lengths in the network (Freeman, 1979). Closeness centrality was measured as (Wasserman and Faust, 1994 or Hansen, 2002) using the following formula: $Cc(ni) = (g - 1)/\sum_{j=1}^{g-1} d(ni, nj)$ where g is the number of investing firms and d(ni, nj) is the geodesies linking firms ni and nj. Summing over all reachable related firms excluding the focal one (g - 1), this gives firm n_i's total closeness score. This measure is standardized, so that a firm has the shortest path length (i.e., is closest) to related firms when the index is one and the longest path length when the index is near zero.

Cash-flow: As all the accounting variables we got net cash-flow from the Orbis database. Cash-flow is the net amount of cash and cash-equivalents available at the end of each fiscal year. We used cash-flow as a proxy of the available resources for corporate venture activities.

Annual R&D expenses: income statement's R&D expenses expresses the firm's propensity to innovate. Chesbrough (2006) stresses the complementary roles of external and internal innovation in the quest of new technologies and new markets. Therefore, the amount of R&D expenses should influence the amount of corporate venture investments and the number of relationships in the VC network.

Annual net sales: As Stated by Park and Vermeulen (2015) "From a startup's point of view, engaging with a corporate investor can be alluring on many fronts big companies have established distribution lines, strategic partners, deep domain intelligence, not to mention an experienced sales force and a global presence. If a startup could access even a sliver of some of these resources, it could make all the difference". Therefore, VC investors have an incentive to invite industrial firms representing the best access to product markets and the annual net sales are a good proxy for that access.

Control variable

Annual amount of VC investments: annual NVCA reports highlight the volatility of VC investments. Investments increase when good opportunities appear and fall quickly when the technology seems mature. Therefore we decided to control for the opportunities link to the IT market using the annual amount of VC investments in the IT industry.

4.2 Model Specification

In order to investigate how industrial firms' relations with VCs and their position in syndication networks influence their decisions of investment we decided to implement GMM System developed by Blundell and Bond (1998). First, an autoregressive model allows to take account of past commitments that may influence the CV investments and the number of relationships in the VC networks. Second, the first differenced model of moments (Arrelano and Bond, 1991) provides general estimators designed for situations with: small T, large N panels, meaning few time periods and many individuals; independent variables that are not strictly exogenous, meaning correlated with past and possibly current realizations of the error; fixed effects; heteroskedasticity and autocorrelation within individuals (Roodman, 2008). However, the properties of this estimator are low when variables are highly persistent: in this case lagged level variables are weakly correlated with the first-difference equations. Blundell and Bond (1998) then show that in the case of highly persistent series, the estimator of the GMM method in system (GMM System) is more appropriate. The validity of the econometric model required to test (1) the first-order and second-order serial autocorrelation of the residuals trough the Arellano and Bond test and (2) The validity of lagged variables used as instruments thanks to overidentifying restrictions Hansen test. Moreover, Roodman (2008) stated that a large collection of instruments, even if individually valid, can be collectively invalid in finite samples because they overfit endogenous variables. Therefore we limit time span in instruments to the two previous years. Finally, we deal with missing values' problem using the recommendations of Holtz-Eakin et al. (1998). That is, we build a set of instruments from the second lag of the dependant variable, one for each time period, and we collapse these instruments set into one vector to generate a meaningful moment condition. We reproduced in the present paper the results of the robust two-step GMM System with a finite-sample correction to the reported standard errors, without which those standard errors tend to be severely downward biased (Windjmeijer, 2005)

5. RESULTS

Descriptive statistics of our study variables are presented in table 2 and pairwise correlations between contemporaneous and 1-lagged variables are reproduced in Appendix. Table 3 and Table 4 show the results from the two-step GMM System models with sample correction and robust standard errors we used. Table 3 highlights the determinants of the annual CV investments of our sample firms while Table 4 sheds light on the factors influencing the relationships number of the industrial firms in the CV network. Finally, Table 5 presents the determinant of the industrial firms' closeness centrality in the VC network.

Tableau 2. Descriptive statistics of our variables study

Variables	Median	Mean	S.D.	Q1	Q3	Interquartile range	Min	Max	Number of observations
annual CV investments (k$)	11306	42844.59	130977.4	3596.95	38327.8	34730.85	0	1922832	1156
co-investors number	2	4.52	8.12	1	4	3	1	86	1156
co-investors (standardized value)	.006	.00	1	-.429	.0013	.4303	-.4341	9.59	1156
closeness centrality	.146	.137	.044	.132	.159	.027	.0004	.2328	1156
closeness centrality (standardized value)	.2026	0.00	1	-.119	.504	.6230	-3.11	2.17	1156
cash-flow(k$)	605 470	3 087 421	6 588 454	53 450	3 039 600	2986150	-28 900	20 776 000	2050
Annual R&D expenses (k$)	402 000	1 246 128	2 038 568	65 361	1 254 193	1188832	0	10 611 000	1439
Annual net sales (M$)	4 562	19 600	35 300	814.371	21 600	20785.63	0	52 708	2060
Total annual IT VC investments (M$)	549	552	7 699	493	618	125	416	672	2060

Tableau 3. The effects of network's position and R&D, cash-flow or net sales on Corporate venture capital investments

	Model III GMM-SYS	Model IV GMM-SYS	Model V GMM-SYS	Model VI GMM-SYS	Model VII GMM-SYS	Model VIII GMM-SYS	Model IX GMM-SYS	Model X GMM-SYS
Prior annual VC investment$_{(t-1)}$	.2863***	.3666***	.3181***	.3412***	.4282***	4093***	.2559***	.3861***
Prior number of co-investors$_{(t-1)}$	.3078**						.9398***	
Prior closeness centrality$_{(t-1)}$		-0.0563						-.5589
annual R&D expenses			.441***					
Prior annual R&D expenses$_{(t-1)}$				.6103***				
Prior annual cash-flow$_{(t-1)}$					.3368**			
Prior annual net sales$_{(t-1)}$						.2244		
Prior number of co-investors$_{(t-1)}$ x Prior annual VC investment$_{(t-1)}$							-.0528**	
Prior closeness centrality$_{(t-1)}$ x Prior annual VC investment$_{(t-1)}$								.0521
IT total VC investment$_{(t)}$	.4346***	.3652***		.3896***	.3277***	.3611***	.045	.003
Constant	4.6381*	2.41*	6.3462***	.004	.002	5.9824***	7.4875***	5.73***
Year dummies	Included	Included	Included	Included	Included	Included	Included	Included
Hansen test χ²(p-value)	.307	.144	.018	.250	.368	.007	.195	.303
Arellano-Bond test for AR(1)	-4.46***	-4.60***	-4.28***	-3.58***	-3.63***	-4.43***	-5.28***	-5.24***
Arellano-Bond test for AR(2)	1.41	1.51	0.03	-0.19	.21	-.20	1.84	2.09*
Number of instruments	39	39	36	35	35	35	53	
Number of observations	529	529	275	204	280	346	669	
Number of groups	98	98	73	55	71	89	153	

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

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Tableau 4. The effects of prior R&D expenses, cash-flow and net sales on the industrial firms' relations number in the VC network.

	Model X GMM-SYS	Model XI GMM-SYS	Model XII GMM-SYS	Model XIII GMM-SYS	Model XIV GMM-SYS	Model XV GMM-SYS	Model XVI GMM-SYS
Prior number of co-investors$_{(t-1)}$	.7919***	.8442***	.7492***	.7771	.4379***	.9218***	.7659
annual R&D expenses$_{(t)}$	.2409*						
Prior annual R&D expenses$_{(t-1)}$		.2152***			-.0412		
Prior annual cash-flow$_{(t-1)}$			.2113*			.1116	
Prior annual net sales$_{(t-1)}$				.1683*			.0479
Prior number of co-investors$_{(t-1)}$ x Prior annual R&D expenses$_{(t-1)}$					.1847***		
Prior number of co-investors$_{(t-1)}$ x Prior annual cash-flow$_{(t-1)}$						-.0517	
Prior number of co-investors$_{(t-1)}$ x Prior annual net sales$_{(t-1)}$							-.0418
IT total VC investment$_{(t)}$	.0047	.066	.1127*	.1183**	.0635	.0881**	.1320***
Constant	.1698	.5098*	.144*	.3911	-.1167	.8034***	.3380
Year dummies	Included	Included	Included	Included	Included	Included	Included
Hansen test χ²(p-value)	.289	.195	.394	.469	.079	.588	.233
Arellano-Bond test for AR(1)	-1.97**	-2.31***	-2.45***	-2.30***	-2.48***	-2.51***	-2.62***
Arellano-Bond test for AR(2)	-1.31	-1.61	-1.48	--1.79	1.67	-1.61	-1.76
Number of instruments	36	36	36	36	45	45	45
Number of observations	284	253	343	356	251	343	356
Number of groups	75	70	89	92	69	89	92

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

Tableau 5. The effects of prior R&D expenses, cash-flow and net sales on the industrial firms' closeness centrality in the VC network

	Model XVII GMM-SYS	Model XVIII GMM-SYS	Model XIX GMM-SYS	Model XX GMM-SYS	Model XXI GMM-SYS	Model XXII GMM-SYS	Model XXIII GMM-SYS
closeness centrality$_{(t-1)}$	.4752***	.5840***	.3557***	.2276***	.0387***	.3951***	.2179***
annual R&D expenses$_{(t)}$	.0085**						
Prior annual R&D expenses$_{(t-1)}$		.0107***			.0352***		
Prior annual cash-flow$_{(t-1)}$			.0037**				
Prior annual net sales$_{(t-1)}$				.0059***			
Prior closeness centrality$_{(t-1)}$ x Prior annual R&D expenses$_{(t-1)}$					-.1833***		
Prior closeness centrality$_{(t-1)}$ x Prior annual cash-flow$_{(t-1)}$						-.0289**	
Prior closeness centrality$_{(t-1)}$ x Prior annual net sales$_{(t-1)}$							-.00855
IT total VC investment$_{(t)}$	-.0108***	-.0029**	-.0011	-.01179***	-.0084***	-.0002	-.0025**
Constant	.2219***	.2263***	.2546	.1888***	-.147***	.1960***	.175***
Year dummies	Included	Included	Included	Included	Included	Included	Included
Hansen test χ^2(p-value)	.123	.195	.184	.469	.089	.223	.100
Arellano-Bond test for AR(1)	-2.24**	-2.15***	-2.1***	-3.21***	-2.17***	-2.41***	-2.62***
Arellano-Bond test for AR(2)	-1.17	-1.12	-0.18	--1.67	-1.57	-1.08	-1.64
Number of instruments	33	36	36	36	45	36	36
Number of observations	284	253	343	399	253	343	356
Number of groups	75	70	89	98	70	89	92

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

Table 2 shows the characteristics of our sample's firms. First, the wide dispersion of the annual CV investment worth noting. Indeed, the standard deviation associated to this variable is 3 times larger than the variable's mean and the interquartile range is 3 times larger than the median. Second, the descriptive statistics associate to cash-flow and annual net sales highlight the size's disparity of our sample's firms. The interquartile range associated to these variables is about 5 times larger than the median and the variables means are higher their the median meaning that the size's distribution of our sample is right skew. Third, on average our sample's firms maintain 4 relations with VC investors but the number of relationships range from 1 to 86. Four, the distribution of closeness centrality appears more concentrate but the weak values take by mean or median indicate that corporate investors are not located in the network's center. Finally, total annual IT VC investments appears stable during the study period.

Table 3 highlights the determinants of annual CV investments. First, it appears that industrial firms are locked in the investors network because of their prior CV investments. These one impact strongly, significantly and positively the amount of annual CV investments. Second, the prior number of relationships influences the annual CV investments (Model III). However it is worth noting that prior CV investments negatively moderate the impact of the prior relationships number on annual CV investments (Model IX) meaning that industrial firms investing large amounts with few VC co-investors have an incentive to invest more and more each year. Third, industrial firms' closeness centrality has no impact on their annual CV investment (Model IV & Model X). Finally, the firm's propensity to innovate (Model V & Model VI) and its available financial resources impact favorably CV investment while firms representing greater access to products markets do not invest more in VC than others industrial firms (Model VIII).

Table 4 presents the determinants of the industrial firms' number of relationships in the VC investors network. Once again, it appears that industrial firms are locked in the investors network because of their past decisions. Hence, the prior number of relationships strongly determines the actual number of relations in the investors network. Moreover the propensity of industrial firms to innovate impacts significantly and positively the relationships number in the investors network (Model X & XI) and Model XIV highlights the complementary effects of the past number of relationships and propensity to innovate on the future number of relationships with VC investors. Finally, the available financial resources of industrial firms and the

access to products markets they represent favor the number of relationships in the investors network but these impacts seems moderately significant.

Table 5 sheds light on the factors influencing industrial firms' closeness centrality. First, one should notice that prior centrality strongly explain future closeness centrality in the VC network. However, the total VC investments in the IT industry negatively impacts closeness centrality of industrial firms. This means that the rise of innovation's opportunities in IT industry attracts VC investors that push industrial firms in a more peripheral position. Thus, high closeness centrality of industrial firms must be linked to weak innovation's opportunities in the studied industry. Second, R&D expenses, cash-flow and net sales significantly influence the industrial firms' closeness centrality (Model XVII, Model XVIII, Model XIX & XX). The effects are positive but the coefficients values associated to these variables highlight very limited impacts on closeness centrality. Third, Model XXI & XII show the moderating impact of prior closeness centrality on the relation between prior R&D expenses or cash-flow and closeness centrality. Hence, R&D expenses or cash-flow amount can substitute to prior closeness centrality to boost future closeness centrality in the VC network. Finally Model XXIII highlights the absence of significant interaction between prior closeness centrality and net sales on future closeness centrality.

6. DISCUSSION

This study was motivated by three important limitations of existing research on CVC. First, we did not find any papers that exclusively focused on CVC strategies investments that followed the IT bubble burst of 2001. Prior studies include data from the 1990's period that generally constitutes more than 70% of the sample's information. However, as the vast majority of industrial firms embedded in VC networks during the 1990's now withdrew it seems hard to pretend that their CVC investments strategies were successful. Second, using GMM system method, Keil et al. (2010) can shed light on the annual revision process operated by industrial firm acting in the VC networks. From an epistemological perspective the use of this sophisticated auto regressive model allows to take into account the effect of past decisions on future choice concerning the same variable. Therefore GMM system fits well to the analysis of firms' strategic decisions when environment is uncertain or when they are compelled to progress by using trial and error process. Third, according to the social networks theory (e.g., Powell, 1990; Gulati et al., 2000; Sorenson and Stuart, 2001) industrial firms should rely on the most central investors in the VC networks in order to capture information about marketa-

ble innovations. However, as the industrial firms enter the syndications at the VClists' invitation (Hochberg et al. 2007) this optimum strategy is by no means assured. Consequently industrial firms may give up pursuing this optimum strategy and focus on a second best's strategy which is to multiply their relationships with the VClists. To the best of our knowledge no paper has yet tried to understand if the industrial firms pursue an optimum or a second best strategy when they enter VC networks.

Our study first highlights the profile of industrial firms engaged in CVC activities after the IT bubble burst. We show that CVC investments concern young firms with a small CVC's experience and using these investments as an additional means to internal R&D in order to improve their innovative capability. This "additional means" seems to be efficient and all else equal the industrial firms show a propensity to increase their CVC investments year after year. Moreover as for internal R&D their CVC investments are constraint by their cash-flow which explains the CVC investments slowdown during the 2007 financial crisis. However, Gompers and Lerner (2000) stress that the VC investments are primarily constrained by the number of good opportunities. It follows that financial investors have a sustainable ability to capture information about marketable innovations while industrial firms may limit their access to this information because of their financial limitations. Thus, our study shows that when the VC investment increases the network's centrality of the industrial enterprises decreases.

Then, we compared the merits and limitations of the two possible relational strategies for the industrial firms embedded in the VC networks. As the prior centrality of the industrial firms does not guide their CVC investments it seems reasonable to claim that they do not pursue this optimum strategy. Moreover the industrial firms propensity to innovate, so the need of information about marketable innovations, or their financial available resources do not lead them to search a central place in the VC network. Therefore it appears that industrial firms focus on the second best strategy when they invest alongside the VClists. Their needs of information lead them to multiply relationships among VClists while their cash-flows limit the number of their relationships in the VC networks.

Finally, Keil et al. (2010) wonder about a possible trade off between an industrial firm and a VClist. According to these authors the former could negotiate the access it represent to the market product against information about innovation owned by the latter. Our study's results partially support the works of Keil et al. On the one the access to market product influences positively the number of relations but this effect is not very significant. On the other hand the

product market access shows a real but very limited impact on the industrial firm's centrality in the VC network. All in all our results indicate that access to the market product is certainly taken into account by the VClists when they invite industrial firms to enter the syndication. However it is far to be their decision's main variable.

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