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What drives CVC investments? An Empirical Test of Social Network Theory Predictions

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Abstract

Using data on corporate venture capital (CVC) investments by 284 US industrial companies between 2001 and 2013, we analyze the CVC expenditures of each based on their prior position in the syndication network and their financial resources. The generalized-method-of-moments models used show that the annual amount of CVC expenditures of these companies depends on the prior number of co-financing relations they have and their cash flows in the previous year, as well as their prior investments. However, the previous centrality of the industrial companies in syndication networks is insignificant, meaning that prior centrality in the VC network does not guide their current CVC expenditures. This result goes against social network theory, which stipulates that the network members strive to improve their centrality in the network they belong.

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1. Introduction

According to Brown et al. (2009), 75% of the technology boom of the 1990s to the massive growth in the supply of financing to young innovative companies during this period. Kortum and Lerner (2000) suggest that despite representing less than 3% of companies' research and development (R&D) expenses between 1983 and 1992, venture capital (VC) was responsible for 10% of US industrial innovations during that period. Industrial companies are minor players in the VC industry dominated by specialized financial institutions (Dushnitsky 2006). Corporate venture capital venturing (CVC) is a type of venture capital in which established companies make direct minority equity investment in privately-held entrepreneurial ventures (Gompers and Lerner, 2000a). According to Basu et al. (2011), industrial companies syndicate 90% of their CVC investments with specialized institutions. Investment syndication by venture capitalists has led to the development of the investor networks (VC networks). Consequently, different types of investors depend on resources controlled by others and the pooling of resources can benefit all parties (Powell et al., 1999).

From the perspective of industrial companies, the efficiency of the VC networks is largely unexplored. First, Basu et al. (2011) stress that CVC research is limited and has only recently attracted renewed interest. Second, CVC studies often are based on 1990's data constituting more than 70% of the sample's information. Hence, these results do not accurately reflect the current situation. Moreover, given that the vast majority of industrial companies embedded in the VC networks during the 1990's have withdrawn their investments, their CVC investments are unlikely to be efficient. Third, social network theory suggests that a central position is the best way to capture information from other network members (Powell et al., 1999). As CVC only accounts for about 17% of VC investments, this "best strategy" may not be possible for all industrial companies. Therefore, the existence of a second-best strategy for industrial companies is questionable. Finally, the literature indicates that venture capitalists (VClists) do not need the industrial companies' financial resources to finance innovative startups. Thus, examining the nature of the resources made available by industrial companies to other network members seems appropriate. Keil et al. (2010) appear to be the first to answer to these questions. However, additional work is needed to confirm the relation between position of industrial companies in the VC networks and the amount of their future CVC investments and between the position in the VC networks and the intangible resources of the CVC parent. Such study is necessary because their methodology involves a debatable measure of centrality, and their data includes period characterized by IT bubble and irrational investor behavior.

The purpose of our study is to examine the relational strategies used by industrial companies to capture information from the VC networks. Our sample consists of 284 US industrial companies that made at least one syndicated CV investment with venture capital companies between 2001 and 2013. This objective leads us to question the nature of the resources these companies made available to the other network members in order to sustain their positions in the VC networks.

Our study contributes to the CVC literature by being the first to question the relational strategies that industrial companies use to capture information from the VC networks. We show that these companies pursue a second-best strategy. This finding highlights the difficulties that they face to integrate the VC networks and opens up new ways of understanding the fluctuating amounts of CVC investments. Second, our results also have practical value by suggesting that the relations with VClists satisfy the industrial companies' information needs. These companies typically renew their CVC investments yearly indicating that this second-best strategy is satisfactory for industrial companies. Moreover, our study shows that the internal R&D expenses complement past relations, helping the industrial companies deepen their embeddedness in the VC networks. Also, the internal R&D expenses can substitute to prior network centrality to improve an industrial company's position in VC networks. Therefore, the informational benefits from embeddedness in VC networks appear to be related to the knowledge that the industrial companies hold about future innovations and that the collaboration between industrial companies and VClists seems to be based on information exchanges about future marketable innovations.

The remainder of the paper is organized as follows. Section 2 reviews the literature and the interests that rely on the industrial company's position in the VC network. Section 3 describes the study's methodology, the dataset and the sample's characteristics. Section 4 presents and explains the empirical results. Section 5 discusses these results and concludes.

2. Theoretical framework

Although the goal of an independent VClist is performance, a CVC fund must balance the strategic objectives of its parent company and its own financial goals. These objectives can be contradictory and create agency conflicts between financed companies and the CVC fund. Thus, analyzing the goals of CVC funds is necessary to understand their influence on value creation of companies they fund. According to Lantz et al. (2011), almost 70% of CVC investors have a combination of strategic and financial objectives. On 15% only invest for strategic value, and 16% for financial return. CVC funds that invest primarily for financial return also seek synergies with the target. These results are consistent with previous studies that identify three principal strategic motives for this type of investment: (1) gain a "window" on emerging technologies (Dushnitsky and Lenox 2005), (2) facilitate development of companies offering complementary products or services (Chesbrough 2000), and (3) identify and monitor potential acquisition targets (Maula and Murray 2001). Therefore, industrial companies should maintain relations with the largest number of VClists in order to enlarge their window on emerging technology and to build a wider ecosystem around their own products.

Hypothesis 1 (H 1). For an industrial company, its prior number of relations in the VC networks is positively associated with the amount of its future CVC investments.

Several studies show that syndication is a widespread strategy among CVC (Manigart et al. 2002). The underlying issue is to know if the position of investors in the syndication network, more particularly their centrality, affects realizing their objectives. VClists and CVClists do not pursue the same goals. The goal of VClists is maximizing the value of the companies they fund, while the CVClits have a combination of strategic and financial objectives. The question of the centrality for these two types of investors should be examined separately, whereas we observe a certain amalgam in the literature.

Some authors contend that VClists and CVClists want to achieve a strong central position in syndication networks in order to get greater performance. This argument is logical for VClists because they want to maximize firm value (Sorenson and Stuart, 2001; Abell and Nisar, 2007; Hochbert et al. 2007). Yet, some criticize this argument for CVClists because they have multiple motivations for investing. Hill et al. (2009) show that centrality in the VC networks has a positive and significant impact on financial performance but an insignificant impact on strategic performance. According to social network theory, centrality in a syndication network is the best measure way to gain access to information available in this network (Noyes et al. 2014).

In fact, the more investors occupy a central positions in the syndication network, the more they accumulate information (not only on the startups in which they invest but also on all the startups financed by the VClists of the syndication network, the technologies that these companies use, and the startups' industry sectors and markets) and consolidate their reputation. If this strategy is effective, then the industrial companies occupying a central position in the networks will attempt to maintain their position in the networks.

H 2. Prior industrial company centrality in the VC networks is positively associated with its future amount of CVC investments.

The other question about centrality concerns how investors can reach and secure this central position. Because of inertia effects, current centrality depends on the previous centrality and the capacity to generate new investments. Central companies occupying network positions are more likely to engage in CVC investments (Noyes et al. 2014). The CVC parent's resources can make reaching a central position quickly possible and secure it. To our knowledge, only the study of Keil et al. (2010) investigates this topic. They highlight a negative relationship 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 valorizes the unique resources held by the CVC parent. Thus, these resources can act like a substitute to the absence of central position of CVC subsidiaries, and allow them to enter syndications that are generally inaccessible to peripheral investors. The resources of the CVC parent can compensate for an unfavorable position in the syndication network.

By providing an improved understanding of VC syndication, Keil et al. (2010) introduce a new element to social network literature because research on this topic argues that networks are exogenous in that they are not caused by or correlated with unobserved attributes of the actors forming these networks (Sorenson and Stuart, 2007). These results help to better understand the mechanisms of resource accumulation and substitution, that are at the center of the relational view of strategic management. This view conceptualizes the inter-organizational relations of a company as relational resources difficult to build and that can bring much value to the company at its founding.

However, the methodology used by Keil et al. (2010) is questionable. They take the previous year's turnover as a proxy to measure the next year's available resources. But a company's capacity for investment depends its cash flows and its financing capacity (by loan or capital). As turnover is partially correlated to cash flows, it is in fact a poor indicator of companies' available resources to invest the next year. The question of the relation between the central position in the syndication networks and the resources of the CVC parent must be confirmed with other measures. In our study, we examine two different types of resources: internal financing (cash flow), and effort to innovate (R&D expenses).

H 3. An industrial company's cash flow is positively associated with its closeness centrality in VC network.

H 4. An industrial company's effort to innovate is positively associated with its closeness centrality in VC network.

3. Methods

To identify the drivers of the syndicated CVC investments we decided to implement the generalized-method-of-moments (GMM) system developed by Blundell and Bond (1998). From an epistemological perspective, this sophisticated auto-regressive model allows us to consider the effect of past investments decisions on future choices with regard to the same variable. In this paper, we reproduced the results of the robust two-step GMM system with a finite-sample correction to the reported standard errors, without which these standard errors tend to be severely downward biased (Windjmeijer 2005).

The data for our analysis come from the Securities Data Corporation (SDC) Venture Economics database, and complemented by accounting information concerning CVC companies from Orbis (BVD).

The SDC database is widely used for VC studies (Keil et al., 2010) and permits identifying industrial companies with corporate venture subsidiaries (CVClists). However, using this database of the VC market imposes geographical, sectorial, and temporal limits. Kaplan and al. (2002) note that SDC mainly provides information on US VC investments start-ups. Consequently, we analyze US industrial companies financing US start-ups. Yet, 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 (IT) start-ups. As the computation of network positions requires substantial data, we choose to focus on the IT industry and select only the industrial companies financing the start-ups of this industry. The bursting of the IT bubble in 2001 led to the withdrawal of the investors attracted by short- term financial profits and major changes in the relative positions of investors in the VC networks. Because of the important decline in CVC investments after the 2001 bursting bubble, we focus on the 2001-2013 period. We identified 284 industrial companies that made at least one syndicated CVC investment with VC companies between 2001 and 2013.

As table 1 shows, our sample consists of young industrial companies. The median company in our sample is 11 years old and made its first CVC investment 9 years ago. Moreover, its activity as a CVC investor is low: during its whole CVC experience, the median company only participated in 11 financing rounds, which is less than 2 rounds per year.

Ernst & Young (2015) regularly stresses the substantial annual variation of corporate venture investments. Thus, we decided to highlight some determinants of industrial companies' decisions to invest in IT startups before focusing on explaining variables of the annual relationships of industrial companies in the VC networks. The dependent variable of our study is the amount of syndicated CVC investment made by industrial companies in IT sector.

Firm CVC investment: Using SDC data, we compute the sum of all dollars invested in a year via all venturing funds of each industrial company (called CVClist or CVC investor).

Our independent variables are one-year lagged firm CVC investment, number of co-investors, closeness centrality, cash flow, and R&D expenses.

Number of co-investors: Using SDC data, we calculate the number of companies with whom each industrial company invests each year. Because the size of the investor network varies each year as well as the possible number of relationships, we standardized this variable.
Closeness centrality: We use the closeness centrality, first proposed by Freeman (1979), to measure path lengths in the network. Closeness centrality is a commonly used measure of centrality (Fershtman and Gandal 2011; Aalbers et al. 2013; Iacobucci and Hoeffler 2016). As defined by Freeman (1979), a node's closeness centrality is the sum of its graph-theoretic distances from all other nodes, where the distance from one node to another is defined as the length (in links) of the shortest path from one to the other:

$$Cc(ni) = (g-1) / \sum_{j=1}^{g-1} d(ni, nj)$$

where g is the number of investing companies and $d(n_i, n_j)$ is the geodesies linking companies ni and nj. Summing the distances of all reachable related companies, excluding the focal one (g - 1), provides company n_i's total closeness score.
The closeness centrality of a network member is recursively related to the sum of the centralities of the other members to which the member is connected. Thus, a network member connected to many well-connected members is assigned a high degree of closeness centrality, whereas a member connected with only a few poorly connected members is assigned a low degree of centrality. This measure is standardized, so that a company has the shortest path length (i.e., is closest) to related companies when the index is one and the longest path length when the index is near zero. According to Borgatti (2005), closeness centrality can be interpreted as an index of the inverse time until arrival of information flowing through the network. In other words, companies with high closeness centrality scores are well positioned to obtain novel information concerning future marketable innovations when they have the most value. Compared to the eigenvector centrality used by Keil et al. (2010), closeness centrality presents two advantages (Bonacich, 2007). First, closeness centrality does not require any hypotheses concerning the shape of the network while eigenvector centrality cannot be used if the study network contains two or more components that are isomorphic images of one another. So the closeness centrality measurement can be undertaken easily while eigenvector centrality measurement demands to analyze the network properties. Second, the closeness centrality measurement is less sensitive than eigenvector centrality to the number of the network relationships. Therefore, the closeness centrality measurement enables disentangling the effects of (1) the centrality and (2) the relationships number on the CVC investments, which is one of our study's objectives.
Cash flow: CVC investment is often a large capital expenditure. Past studies such as Fazzari and Athey (1987) and Dushnitsky and Lenox (2005) find that companies with greater cash flow are more likely to have the financial flexibility to invest. Following Dushnitsky and Lenox (2005), we used net cash- flow as a proxy of the available resources for financing corporate venture activities. We use the Orbis database to get net cash flow, which is the net amount of cash and cash-equivalents available at the end of each fiscal year.
R&D expenses: According to Chesbrough (2006) R&D expenses shown on the income statement capture a company's effort to innovate. He stresses the complementary roles of external and internal innovation in the quest for new technologies and new markets. Therefore, the amount of R&D expenses should influence the amount of CVC investments and the number of relationships, as well as the position, in the VC network.
We also use the only two control variables: Size and IT total VC investment because Roodman (2007) indicates that a large collection of instruments, even if individually valid, can be collectively invalid in finite samples because they over-fit endogenous variables.
Size: According to Aviral and Raveesh (2015), we use the natural logarithm of *Net Sales* as a proxy for company size. They discuss the logarithm of total assets as an alternate; however, they show the net sales as a better proxy for the measure of size. Moreover, "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" (Park and Vermeulen 2015). Therefore, VC investors have an incentive to invite industrial

companies that represent the best access to product markets, and annual net sales are a good proxy for that access.
IT total VC investment: National Venture Capital Association (NVCA) reports highlight the volatility of VC investments. Investments increase when good opportunities appear and drop sharply when the technology is mature. Therefore, we control for the opportunity link to the IT market using the annual amount of VC investments in the IT industry. In fact, total measured of IT venture capital investment reflects both supply and demand for VC in IT sector, and thus the overall functioning of the VC market, which depends on GDP growth and institutional factors such as the possibility for the venture capitalist to exit the engagement through an initial public offering (Kanniainen and Keuschnigg, 2005).

4. Empirical Results

Our study first highlights the profile of industrial companies that have been engaged in CVC activities since the IT bubble burst in 2001. Table 1 shows that CVC investments concern young companies with limited CVC experience. The descriptive statistics associated to these companies (table 2) highlight many interesting points.
First, the wide dispersion of the annual CVC investment is worth noting. The standard deviation associated with this variable is three times larger than the variable's mean, and the interquartile range is three times larger than the median. Second, the descriptive statistics associate with cash flow and net sales highlight the size disparity between our sample companies. The interquartile range associated with these variables is approximately five times larger than the median, and the variables means are higher than the median indicating right skewness.
Third, on average, our sample companies maintain four relationships with VC investors, but the number of relationships range from 1 to 86. Fourth, the variation in closeness centrality appears more concentrated, but mean and median values indicate that corporate investors are not located at the network's center. Finally, the descriptive statistics show that total annual VC investments in IT appear stable over the study period.
Table 3 points out the drivers of CVC investments of industrial companies. First, industrial companies show a propensity to increase their CVC investments year after year (Model I to Model VI). Therefore CVC investments seem fulfill the objectives that industrial companies assign to them. Second, internal R&D expenses positively and strongly guide CVC investments. Consequently, this latter appears as an additional means to the former to improve the innovative capabilities of the company (Model I). Third, the CVC investments are significantly constrained by the company's cash flow (Model II). This explains why the CVC investments slowed down during the 2007 financial crisis. However, Gompers and Lerner (2000b) stressed that CVC investments are primarily constrained by the number of good opportunities. Financial investors are thus able to consistently capture information about marketable innovations, while industrial companies may have limited access to this information because of their financial limitations.
We compare the benefits and limitations of two possible relational strategies for the industrial companies embedded in the VC networks (Model III to Model VI).
On the one hand, Model III shows that the prior number of co-investors significantly and positively affects the current amount of CVC investments, and conducts to validate the hypothesis 1 (H1). However, Model VI highlights the moderating effect of past CVC investments on the relation between prior number of co-investors and the current amount of CVC investments. All in all it appears that the CVC investments aim to maintain relationships with VC investors: the more an industrial company has initiated relationships with VC investors the more it has to invest year after year. Nonetheless, an industrial company that has already signaled its capacity to invest large CVC amounts in the past can lower its current CVC investments. Since the investment duration of industrial company in a start-up is about three years (Hochberg et al. 2007) this result is not surprising: industrial companies, able to show their capacity to invest punctually large amounts, have a superior ability to maintain their co-investors relationships.
On the other hand, the prior closeness centrality of the industrial companies has no significant impact on their current CVC investments (Model IV) while the Model VI doesn't indicate any effect of the prior CVC investments on the relation between the past closeness centrality of the industrial company and the amount of its current CVC investments. Therefore it seems that the search of a central position

doesn't guide the CVC investments of an industrial company: First the descriptive statistics indicate that the closeness centrality of our companies sample is low, second we show that the prior closeness centrality of industrial companies doesn't guide their current CVC investment. Finally, using sophisticated autoregressive model we fail to highlight any relation between the past CVC investments and the prior closeness centrality on the one side and the current CVC investments on the other side. These results conduct us to reject the hypothesis 2 (H2).

Table 4 reveals the factors that influence industrial companies' closeness centrality. R&D expenses and cash flow significantly influence industrial companies' closeness centrality. Model XIII and Model XIV show the moderating effect of prior closeness centrality on the relationship between prior R&D expenses or cash flow and future closeness centrality.

Hence, the cash flow amount but mainly R&D expenses can substitute for prior closeness centrality to boost future closeness centrality in the VC network. The hypotheses 3 and 4 are validated. This result is similar to Keil et al. (2010) who claim that unique resources held by the industrial company (e.g., the knowledge deriving from internal innovative efforts) can substitute for the lack of prior centrality and allow them to invest with more central venture capitalists. These special relationships influence the industrial companies' closeness centrality and thereby improve their access to the external information about future marketable innovation.

In sum, the results of the GMM system we have implemented indicate that prior co-investors relationships guide future CVC investments. Contrary to the social network theory predictions, the industrial companies embedded in the VC networks don't attempt to reach a central position and their current closeness centrality doesn't guide their futures CVC investments. Therefore, CVC investments could be considered as relational investments that R&D active industrial companies makes in order to diversify their information sources about future marketable innovations.

Our sample shows that the size of companies involved in CVC investments is very different. It means that this sort of strategy is not exclusively employed by very big companies. Indeed, the size is a significant variable in all models and could be considered as an important determinant of the CVC investments. In other terms, the size affects the available resources of companies (Cash flow and R&D expenses), and the capability to make external investment. Moreover, the size influences the opportunities of investment. Particularly, VC investors have an incentive to invite industrial companies in the capital of startups in which they have already invested (in their network) if they think that these industrial companies could be a mean to develop the owned startups and provide them an access to market products.

5. Conclusion

Using more recent data and a measure of centrality that disentangles the centrality measure from the number of relationships in VC networks, our result's study partially support the claims of Keil et al. (2010). On the one hand, we show that industrial company's unique resources boost their centrality in the VC network, even if those effects appear to be very limited. On the other hand, our study shows that these unique resources influence also the number of relationships that industrial companies have in VC networks. Industrial companies' unique resources are thus apparently a means of establishing relationships with any VClist, not just the more centrally positioned among them in the VC networks. Finally, our study shows that the industrial companies rely on the previous number of relationships in the VC networks to determine the current amount of CVC investments, while prior centrality has no effect on this decision. In terms of an investment decision highlighting a firm's strategy, the industrial companies do not try to improve their centrality in the VC networks. They pursue a second-best strategy, i.e., maintaining their current relationships in the VC networks. Overall, our results indicate that the VClists indeed consider access to the product market when they invite industrial companies to join syndications. However, it is far from being the primary variable influencing their decision making process.

As with all studies, our research has a number of limitations that should be noted. The two main limitations concern the data and the selected variables. To generate homogeneous results, we only included companies in the IT sector. We also chose a specific measure of centrality, but comparing the results generated with different measures would be interesting. Moreover, to complete this research, future studies might conduct in-depth qualitative inquiries. The paper also gives interesting opportunities and open as many lines of research. For example, what is the impact of complementary resources on corporate investors' centrality, contingent on environmental factors such as the economic cycle? Are the syndication practices and the relationships between VClists and CVClists observed in the US the same as those in other countries?

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Appendix

Table 1. Profile of CVC investors

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

Table 2. Descriptive statistics of variables used in the study

Variables	Median	Mean	S.D.	Q1	Q3	Interquartile range	Min	Max
CVC investments ($k)	11,306	42,844.59	130,977.4	3,596.95	38,327.8	34,730.85	0	1,922,832
Number of co-investors	2	4.52	8.12	1	4	3	1	86
Co-investors (standardized value)	.006	.00	1	-.429	.0013	.4303	-.4341	9.59
Closeness centrality	.146	.137	.044	.132	.159	.027	.0004	.2328
Closeness centrality (standardized value)	.2026	0.00	1	-.119	.504	.6230	-3.11	2.17
Cash flow ($k)	605,470	3,087,421	6,588,454	53,450	3,039,600	2,986,150	-28,900	20,776,000
R&D expenses ($k)	402,000	1,246,128	2,038,568	65,361	1,254,193	1,188,832	0	10,611,000
Net sales ($M)	4,562	19,600	35,300	814.371	21,600	20,785.63	0	52,708
Total annual IT VC investments ($M)	549	552	7,699	493	618	125	416	672

Table 3. The effects of network's position, R&D, cash flow or net sales on CVC investments

	Model I SYS-GMM	Model II SYS-GMM	Model III SYS-GMM	Model IV SYS-GMM	Model V SYS-GMM	Model VI SYS-GMM
Prior CVC investment$_{(t-1)}$	.4278***	.4699***	.2953***	.3783***	.4785***	.5573***
Prior R&D expenses$_{(t-1)}$	.5148***					
Prior Cash flow$_{(t-1)}$		.3147**				
Prior number of co-investors$_{(t-1)}$			.2996**		.8452***	
Prior closeness centrality$_{(t-1)}$				-0.0674		-.2136
Prior number of co-investors$_{(t-1)}$ x Prior CVC investment$_{(t-1)}$					-.04863**	
Prior closeness centrality$_{(t-1)}$ x Prior CVC investment$_{(t-1)}$						.1482
Net sales $_t$	.0891***	0.1149***	.0456***	.09781**	0.0587***	0.2217**
IT total VC investment$_{(t)}$	.6852***	.3185***	.5142***	.2991***	.6211***	.1784**
Constant	.0160	.0044	4.8745*	2.6918*	5.2477**	4.3632**
Year dummies	Included	Included	Included	Included	Included	Included
Hansen test χ^2(p-value)	.196	.395	.472	.305	.589	.234
Arellano-Bond test for AR(1) (p-value)	.004	.005	.000	.009	.003	.007
Arellano-Bond test for AR(2) (p-value)	.154	.323	.253	.163	.110	.403
Number of instruments	35	35	39	39	53	53
Number of observations	204	280	529	529	669	669
Number of groups	55	71	98	98	153	153

Note: Two-step SYS-GMM (Generalized Method of Moments) estimation with finite-sample correction and robust standard errors.
The dependent variable: *CVC investment* is the sum of all dollars invested in a year via all venturing funds of each industrial firm. The variable *R&D expenses* is the annual amount of R&D expenses of each industrial firm each year. *Cash flow* is the net amount of cash and cash-equivalents available at the end of each fiscal year of each industrial firm. *Net Sales is* the natural Logarithm of Net Sales at the end of each fiscal year of each industrial firm.
Number of co-investors is calculated by the number of companies with whom each industrial firm invests each year. *Closeness centrality* is our measure of centrality of each industrial firm each year. The control variable called *IT total VC investment* is the annual amount of VC investments in the IT industry each year. Financial variable are normalized.
$*p < 0.1$; $**p < 0.05$; $***p < 0.01$

Table 4. The effects of prior R&D expenses and cash-flow on the industrial firms' closeness centrality in the VC network

	Model XI GMM-SYS	Model XII GMM-SYS	Model XIII GMM-SYS	Model XIV GMM-SYS
Closeness centrality$_{(t-1)}$	0.5840***	0.3557***	0.0387***	0.3951***
Prior annual R&D expenses$_{(t-1)}$	0.0107***		0.0352***	
Prior annual cash-flow$_{(t-1)}$		0.0037**		
Prior closeness centrality$_{(t-1)}$ x Prior annual R&D expenses$_{(t-1)}$			–0.1833***	
Prior closeness centrality$_{(t-1)}$ x Prior annual cash-flow$_{(t-1)}$				–0.0289**
IT total VC investment$_{(t)}$	–0.0029**	–0.0011	–0.0084***	–0.0002
Constant	0.2263***	0.2546	–0.1470***	0.1960***
Year dummies	Included	Included	Included	Included
Hansen test χ^2 (p-value)	.195	.184	.089	.223
Arellano-Bond test for AR(1)	–2.15***	–2.1***	–2.17***	–2.41***
Arellano-Bond test for AR(2)	–1.12	–0.18	–1.57	–1.08
Number of instruments	36	36	45	36
Number of observations	253	343	253	343
Number of groups	70	89	70	89

Note:*p < 0.1; **p < 0.05; ***p < 0.01