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RESEARCH ARTICLE

The Effects of Venture Capital Network Centrality on Earnings Management and Profitability of Portfolio Company: Evidence from the U.S. Market

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Based on a sample of 788 U.S. venture capital-backed IPO companies from 2006 to 2015, this research evaluates the impact of network centrality, venture capital (VC), and earnings management on the future profitability of VC-backed portfolio companies. The results suggest that companies backed by VCs with higher network centrality or that are "more centralized" are likely to have better future profitability after an IPO, even with the use of accrual-based earnings management.

Keywords: Venture Capital, Earnings Management, Network Centrality

JEL Codes: G30

One of the most effective ways to support businesses is with venture capital (VC), which assists firms in commercializing and driving growth (Rin, Hellmann, & Puri, 2013). According to Chemmanur, Krishnan, and Nandy (2011), VC-backed companies are more efficient and perform better than those without VCs. During an IPO, there is an information asymmetry between outside investors and internal representatives known as "insiders" (DuCharme, Malatesta, & Sefcik, 2001; Rao, 1993; Teoh, Wong, & Rao, 1998). Insider investors can alter financial data to enhance stock prices through a process referred to as "earnings management" (Jenkinson, Ljungqvist, and Ljungqvist (2001). This behavior between public market investors and insiders creates a principal-agent conflict of interest.

VCs help companies go public by utilizing various promises to safeguard their investments (Barry, Muscarella, Peavy, & Vetsuypens, 1990). The existence of VCs tends to stifle earnings management while promoting corporate governance (Brau & Johnson, 2009; Morsfield & Tan, 2006). However, VC firms are subject to pressure from syndicate members (Bruton, Filatotchev, Chahine, & Wright, 2010) . Misalignment of goals can nurture conflicts of interest amongst principals, affecting their monitoring position

(Hochberg, Ljungqvist, & Lu, 2007). Some syndicate members aim to implement earnings management methods, a strategy described by grandstanding theory (Gompers, 1996).

Network centrality measures a person's connections, position, and status inside a network relative to three relational aspects: degree, closeness, and betweenness. Thus, when referring to VCs, network centrality indicates how well-connected VCs are in a network. VCs may utilize their networks to obtain data from their contacts and determine which strategy and amount of earnings management are best for their company. Greater undetected earnings management can benefit the VC, such as increased investor returns, and improve the VC's reputation by allowing portfolio companies to increase financial returns. VCs with higher network centrality may try to limit the negative consequences of high-risk activities like earnings management, as they may fear damaging their reputation. However, well-connected VCs are subject to less scrutiny, allowing them to engage in earnings management while avoiding detection. Because syndicated investments are favored over single-VC investments, the interconnection between VCs is critical to a sector (Lerner, 1994; Sahlman, 1990).

The present research focuses on co-investment networks caused by VC syndication. These networks are selected for this study because they are relatively straightforward to monitor and can influence the primary driver of VC success. We use three centrality measures to investigate the relationship between VC network centrality measures, portfolio company performance, and earnings management. First, we are concerned with the degree, which evaluates the number of connections an individual has within a network. Second, we consider closeness, a measure of network quality determined by Eigenvector centrality, developed by Bonacich (1972, 1987). Third, we measure betweenness, an indicator of the level at which one VC can mediate between other VCs.

Although the results of previous studies are inconsistent regarding how VCs' network centrality and earnings management relate to their economic performance, the findings typically indicate that adverse financial outcomes (decreased future profitability, accuracy of analysts' estimates, long-term stock performance) all stem from earnings management. In our research, we sought to determine whether the network centrality of VCs improves or worsens financial performance in companies practicing earnings management. Initially, the difference in one-year-ahead return on assets (ROA) is used to measure projected profitability. Then two sets of interaction terms are applied. The first is the interaction effect of network centrality measures and discretionary accruals (a measure for accrual-based earnings management) on the future change in ROA. The second is the interaction terms of network centrality and change in the current year's ROA.

This study aims to investigate the relationship between three dimensions: VC network centrality, earnings management, and outcomes on the economic performance of portfolio companies. Therefore, the following research question was formulated: Do more network-centralized VCs relate to the good subsequent economic performance of VC-backed companies, even with the use of earnings management?

The remaining sections are grouped as follows. Section 2 examines pertinent past literature. Section 3 outlines the study's hypotheses. The fourth section details the study's data and methods. Section 5 discusses the results of empirical studies, whereas Section 6 provides a conclusion.

Literature Review

The ability of a VC to acquire data and pass on competitive advantages depends on the VC's reputation (Kreps & Wilson, 1982; Milgrom & Roberts, 1990; Shapiro, 1983). According to previous studies, a VC's ability to acquire new capital is related to its reputation as much as its fund's performance. According to Gompers (1996), early-stage VC firms are more likely to incur costs by prematurely bringing a portfolio company public. Emerging VCs seek to establish positive reputations by bringing portfolio companies public and using an underpricing strategy (Neus & Walz, 2005). Given the difficulties in determining how good VCs are at selecting and nurturing firms, an IPO is the most effective way to determine their ability. Most financial returns for limited partners (LPs) come from a portfolio company that goes public (Sahlman, 1990). Potential LPs base their VC investment selections on the assumption that highly skilled VCs select start-ups that demonstrate the potential to go public.

Because investments are typically syndicated, determining the impact of a particular VC firm on the earnings management of a company going public can

be challenging (Lerner, 1994). The inclusion of various and diverse syndicate members has the advantage of safeguarding reputations, as it becomes challenging to accurately delineate each member's participation (Sorenson & Stuart, 2008). Although syndication allows each VC to diversify its company-specific risks and harness complementary skills, it can also lead to other agency conflicts, particularly in the run-up to IPOs. According to Cumming (2006), when ownership concentration decreases, each syndicate member is less motivated to perform a monitoring function, resulting in free riding. Individual VCs find it more challenging to root out opportunism among other syndicate members and business insiders as their networks become more diverse. Higher coordination expenses are a further potential consequence of syndication, impairing collective monitoring of management behavior and impeding coordinated responses to managerial opportunism. Opportunistic managers grasp the chance to implement earnings management during IPOs due to principal-principal conflicts of interest. Coordination issues can also stymie timely and effective decision-making (Cumming, Siegel, & Wright, 2007), whereas information asymmetry amongst syndicate members can lead to conflicts of interest (Cumming, 2006). If VCs feel forced to grandstand, they collaborate with a company's management to manipulate results. The greater a VC firm's reputation, the earlier its business goes public.

The amount to which one actor engages in connections with others is used to determine network centrality. Two VCs investing in a single portfolio business are categorized as "tied" (Hochberg et al. (2007). Because networks are fluid, the present research relies on five-year adjacency matrices and the three centrality measures (degree, closeness, and betweenness). The number of single VCs co-investing with others is indicated as the degree, which delineates the number of unique ties linking each VC. Closeness, a quality metric, is determined by the Eigenvector (Bonacich, 1972, 1987), which is based on the importance of other players connected to the actor. Betweenness evaluates the importance of the actor, which is relied upon by other players to form network links.

Syndication enhances deal flow for three principal reasons: sharing promising opportunities among VCs to earn reciprocal invitations in the future (Lerner, 1994); sounding out the willingness of other VCs to help investors better vet opportunities when their viability and return potential are uncertain (Sah & Stiglitz, 1986; Wilson, 1968); and creating a synergy of expertise by crossing geographical and sector boundaries to enable portfolio diversification (Stuart & Sorenson, 2003). Furthermore, networking across syndicates can add value to the companies in a VC's portfolio through the diffusion of data, resources, and contacts (Bygrave, 1988). Examples of such diffusion include increasing the number or types of investors who will take an interest in an IPO launch or gaining access to new partners who can form strategic alliances with companies where they already have an investment. Equally, forging robust ties with fellow VCs may result in follow-on VC funding and the possibility of accessing peers' relationships with valuable service providers.

Hypothesis Development

According to the earnings management studies, firms that use accrual-based earnings management are likely to experience long-term deterioration in economic performance, such as when estimations of future profitability are reduced or when the firms perform poorly in the stock market over an extended period (Gunny, 2005; Sloan, 1996; Xie, 2001). According to the social network literature, however, firms whose boards of directors are well-connected can, in contrast, gain higher risk-adjusted stock returns (Larcker, So, & Wang, 2013). This situation triggered our interest in analyzing whether the long-term economic performance of firms, as indicated by changes to future profitability, is affected by the earnings management strategy by VCs with different levels of network centrality.

Moreover, VCs can benefit from syndication networks in knowledge, connections, and resources (Bygrave, 1988), allowing them to add value to the firms in their investment portfolios. Such benefits include reaching a broader range of investors at an IPO or arranging strategic partnerships. When relationships with other VCs are present, there is a higher chance that follow-on VC funds will be forthcoming, as will access to providers of services, such as recruitment and financial advisory. Thus, our hypothesis was formulated as follows:

Hypothesis: There is a positive association between a more network-centralized VC and good subsequent economic performance of VC-backed companies, even when earnings management is used.

Method

This research is based on datasets from the Thomson Reuters' Eikon database (Thomson Reuters Eikon., 2022). Variables were winsorized at 5% and 95% to remove the influence of outliers. We compiled a list of all 788 initial public offerings (IPOs) in which venture capitalists participated between 2006 and 2015. This timeframe was selected to avoid the dot-com bubble of 2000 (Arthurs, Hoskisson, Busenitz, & Johnson, 2008; Beatty & Zajac, 1994). The undirected centrality variables focused on a VC syndicate formed by co-investing in a single portfolio company. As a result, we defined the syndicate to be set up company by company and comprised of all VCs holding a stake in each portfolio company.

We built our model based on previous research to apply it to accrual-based earnings management (P. M. Dechow, Sloan, & Sweeney, 1995; Francis & Yu, 2009; Jones, 1991; Kothari, Leone, & Wasley, 2005). Discretionary accruals are computed from the residual (ε), using the modified Jones cross-sectional model:

$$\frac{TACC_t}{A_{\tau-1}} = \alpha_1\left(\frac{1}{A_{\tau-1}}\right) + \alpha_2\left(\frac{\Delta REV_\tau - \Delta REC_\tau}{A_{\tau-1}}\right) + \alpha_3\left(\frac{PPE_\tau}{A_{\tau-1}}\right) + \varepsilon \quad (1)$$

where ΔREV_t is year *t* revenue minus year *t-1* revenue, ΔREC is the difference in account receivables, and PPE_t is the gross property, plant, and equipment at year *t*. $TACC_t$ is the total accrual for year *t* and is computed by subtracting the change in current assets (non-cash) from current liabilities (excluding current debt and current portion of long-term debt). The variables were divided by lagged total assets to normalize them.

Earnings quality is a critical component of company financial information; the higher the earnings quality, the more accurate the information available to investors seeking to forecast a company's future performance. However, informational risk represents an unquantifiable risk factor for investors and impacts how the price of a firm's stocks develops over time. Moreover, the network centrality level may relate to the portfolio company's earning quality. Hence, testing the potential association between VC network centrality and improving or declining economic performance will offer valuable insights. Larcker et al. (2013) found that the connectivity level of a board of directors can indicate higher growth in ROA; however, this change can escape the attention of analysts. Hence, boards whose members have higher network centrality are likely to oversee firms that achieve higher risk-adjusted returns. We mined the literature to design a test to determine the truth of this contention.

A pooled regression and panel fixed effect regression with firm and year fixed effects were run to determine the relationship between three factors: VC network centrality, presence of earnings management, and future changes in ROA, as suggested by Qiu (2019).

$$(\Delta ROA_{t+1}) = \beta_0 + \beta_1 \Delta ROA_t + \beta_2 EM_t + \beta_3 Centrality_t + \beta_4 \Delta ROA_t * Centrality_t + \alpha_5 EM_t * Centrality_t + \beta_6 Controls_t + \varepsilon_t \quad (2)$$

As the dependent variable, a one-year forward difference in ROA was used in the regression. The current change in ROA was controlled for, and the level of discretionary accruals and network centrality measures were explanatory variables. The term "earnings persistent" is frequently seen in the literature about the capability to use past or current earnings data to forecast future earnings (P. Dechow, Ge, & Schrand, 2010; P. M. Dechow & Dichev, 2002; Richardson, Sloan, Soliman, & Tuna, 2006). Interactions between network centrality and differences in ROA were considered to determine the extent to which current earnings can predict future earnings relative to a VC's network centrality. Leverage, revenue growth, and firm size were used as control variables.

Results

Table 1 shows descriptive statistics for all the variables in the analysis. The variables of particular interest are the one-year forward return on assets, which is the proxy for the future profitability of the firms, and three measures of VC network centrality. In Table 2, we provide the pairwise correlation coefficients for all variables included in the study with a significance threshold of 0.01%, 0.05%, and 0.1%.

Table 1. Descriptive Statistic for the Future Difference in Return-on-Assets Analysis

	N	Mean	Std. Dev.	Median	min	max
Abnormal Accrual	788	-.01302	0.49844	-.0857	-1.1212	2.57865
One-year forward return on assets	738	-.17157	0.41905	-.0497	-2.73433	.28325
Return on assets	788	-.18766	0.39677	-.06385	-2.0786	.2998
Network measures						
Degree	473	.05647	0.04995	.043	0	.213
Eigenvector	473	.07002	0.06759	.052	0	.236
Betweenness	473	.00616	0.00981	.002	0	.052
Revenue growth	618	.58584	0.81282	.36145	-.4584	4.8987
Leverage	788	.6916	5.12102	.5674	-28.3839	22.235
Firm size (revenue)	788	2.575e+08	6.70781e+08	91054500	0	5.200e+09

Table 2. *Pairwise Correlations for the Future Difference in Return-on-Assets Analysis*

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Abnormal Accrual	1.000								
(2) 1Y forward ROA	-0.035	1.000							
	(0.337)								
(3) ROA	0.093*	0.682*	1.000						
	(0.009)	(0.000)							
(4) Degree	0.026	0.004	-0.040	1.000					
	(0.568)	(0.926)	(0.387)						
(5) Eigenvector	0.031	-0.005	-0.032	0.848*	1.000				
	(0.500)	(0.913)	(0.491)	(0.000)					
(6) Betweenness	0.027	0.011	-0.046	0.896*	0.764*	1.000			
	(0.557)	(0.821)	(0.316)	(0.000)	(0.000)				
(7) Revenue growth	0.072	-0.017	-0.028	0.202*	0.149*	0.240*	1.000		
	(0.072)	(0.680)	(0.480)	(0.000)	(0.004)	(0.000)			
(8) Leverage	-0.034	0.026	0.100*	0.108*	0.070	0.087	-0.044	1.000	
	(0.336)	(0.484)	(0.005)	(0.019)	(0.130)	(0.059)	(0.275)		
(9) Firm size	-0.004	0.189*	0.222*	0.018	0.060	-0.045	-0.087*	0.076*	1.000
	(0.920)	(0.000)	(0.000)	(0.700)	(0.196)	(0.327)	(0.031)	(0.033)	

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

As the study demonstrates, network centrality metrics are highly correlated. Thus, it is more acceptable to do regression analysis on each network centrality metric individually to avoid multicollinearity.

Table 3 presents the regression results on VC network centrality, earnins management, and future profitability of VC-backed portfolio companies. The dependent variable was a one-year forward difference in return on assets. Key independent variables were the network centrality measures degree, eigenvector, and betweenness. Interaction terms between abnormal discretionary accruals and VC network centrality measures were also added.

We used the panel regression fixed-effect model suggested by the Durbin–Wu–Hausman test. We added time-fixed effect models into the analysis to further

Table 3. *Regression Analysis of the Future Difference in Return-on-Assets*

Dependent variable: Future Change in ROA	(1)	(2)	(3)	(4)	(5)	(6)
	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Network measures						
VC Degree	-	-	-	-	-	-
VC Eigenvector	-	-	-	-	-	-
VC Betweenness	-	-	-	-	-	-
Modified Jones DACC	0.155	0.135	0.117	0.0866	0.0792	0.0686
	(0.118)	(0.0987)	(0.111)	(0.114)	(0.0869)	(0.0996)
Change in ROA	-0.986***	-0.953***	-0.866***	-1.024***	-1.036***	-0.900***
	(0.0698)	(0.139)	(0.0533)	(0.0844)	(0.158)	(0.0705)
Interaction terms:						
VC Degree x DACC	-0.390			0.173		
	(1.827)			(1.569)		
VC Degree x Change in ROA	6.111***			5.914***		
	(1.750)			(2.084)		
VC Eigenvector x DACC		0.524			0.504	
		(1.280)			(1.245)	
VC Eigenvector x Change in ROA		2.330			3.009	
		(2.182)			(2.220)	
VC Betweenness x DACC			7.591			6.065
			(15.37)			(14.32)
VC Betweenness x Change in ROA			26.49***			19.90
			(9.071)			(14.64)
Revenue growth	-0.0427	-0.0481	-0.0262	-0.00545	-0.0106	0.00576
	(0.0684)	(0.0784)	(0.0731)	(0.0816)	(0.0878)	(0.0876)
Leverage	-0.0130	-0.0133	-0.0120	-0.0162	-0.0171	-0.0152
	(0.0143)	(0.0154)	(0.0153)	(0.0121)	(0.0130)	(0.0127)
Firm size	0	7.12e-11	7.83e-11	1.24e-10	1.46e-10	1.68e-10
	(9.37e-11)	(1.12e-10)	(9.41e-11)	(1.39e-10)	(1.40e-10)	(1.39e-10)
Constant	-0.0426	-0.0488	-0.0691	0.184	0.212	0.180
	(0.0464)	(0.0631)	(0.0565)	(0.388)	(0.401)	(0.402)
Observations	230	230	230	230	230	230
R-squared	0.743	0.737	0.740	0.784	0.780	0.779
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	YES	YES	YES
Hausman endogeneity test (p-value)	0.1019	0.1019	0.1019	0.3985	0.3985	0.3985

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

control for the time effect. The control variables were: leverage, revenue growth, and firm size. To mitigate the endogeneity issue, we performed the Hausman endogeneity test. The result is also reported in Table 3 and found no endogeneity problem.

The findings concerning how VC network centrality and use of discretionary accruals impact future profitability are presented in Table 3, with all columns showing significantly negative coefficients ($p < .01$) of the current change of ROA. Hence, it can be inferred that decreased future change in ROA can be forecasted by increased current change in ROA. This finding suggests that the coefficients for discretionary accruals are not significantly negative ($p < .05$), which contradicts previous studies. Thus, it appears that accruals-based earnings management has no statistically significant effect on the future change of ROA.

Turning to centrality measures, significantly positive coefficients ($p < .05$ in two of the three measures) are revealed for interactions between the future change of ROA and network centrality measures. It can therefore be inferred that for companies supported by VCs with higher network centrality, the current change of ROA is less reliable in predicting the future change of ROA. From our findings, the current change of ROA indicates a negative prediction for future change of ROA; therefore, a reduction in predictability indicates a "better" future change of ROA.

Thus, this analysis confirms our hypothesis that there is a positive association between a more centralized VC and good subsequent economic performance of VC-backed companies, even when earnings management is used. In other words, companies backed by "more network-centralized VCs" are likely to perform better after an IPO, even with earnings management.

Conclusion

This study delves into the connection between VC network centrality, earnings management, and a portfolio company's future economic performance. The findings reveal that even with earnings management, there is a strong correlation between VC network centrality and the future profitability of VC-backed portfolio companies. This confirms that companies backed by VC with higher network centrality gain more value from investors. To our knowledge, this analysis is the first to show a relationship between VC network centrality, a company's earnings management approach, and future economic performance, pushing the frontier of network studies and venture capital research. These insights are helpful for businesses looking to collaborate with the right VC to raise funds.

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Appendix: Network Analysis Methodology

The primary purpose of network analysis, which focuses on the interactions observed among a group of economic participants, is to investigate the properties that characterize the networks. Network analysis is a crucial subject in social science. One of the main goals of network analysis is to identify which players have the most influence. This is achieved by determining the "centrality" of a network position based on the volume of connections an actor engages in.

Graph theory is used in network research to define centrality more precisely. In graph theory, a network is represented by a square "adjacency" matrix, where the cells represent the connections among the network's members. Only directed matrices distinguish between the source and recipient of a tie. Adjacency matrices can be "undirected" or "directed." Networks are dynamic because their links can alter, and joining or leaving the network can impact each VC's centrality. Therefore, we used five-year trailing frames to create our adjacency matrices and concentrated on *degree*, *eigenvector*, and *betweenness* as key centrality metrics. The quantity of connections a network participant has is known as *degree* centrality. An actor's power, or centrality, increases with the number of links they have, as a higher number of links grants them more access to resources like information and contacts. The following equation may be used to determine each VC's *degree* centrality:

$$\mathrm{VC_i} = \sum_j p_{ij}$$

where p_{ij} equals one if at least one syndication relationship exists between VCs *i* and *j*. Otherwise, p_{ij} equals zero.

Closeness assesses the quality of a connection. In contrast, *degree* represents the number of connections. "*Eigenvector* centrality" (Bonacich, 1972, 1987) is a useful metric of proximity that weighs an actor's links to other network members according to the significance of the actors to whom they are related. The following formula gives the *eigenvector* centrality informally:

$$\mathrm{VC_i} = ev_i = \sum_j p_{ij} ev_j$$

The value is normalized in a network with *n* participants using the largest *eigenvector* centrality measure. When forming connections inside the network, players on whom many others must rely are influenced by *betweenness* traits. Specifically, *betweenness* is a proxy for the degree to which a venture capitalist may serve as an intermediary by connecting venture capitalists with complementary talents or investment possibilities that do not already exist in a direct relationship. The following formula may be used to determine the *betweenness* centrality:

$$\mathrm{VC_i} = \sum b_{jk} \forall i \neq j \neq k$$

Where b_{jk} is the proportion of all paths linking actors *j* and *k* that pass through actor *i*.