Do Public Firms Follow Venture Capitalists? *

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Abstract

In this paper, I show that venture capitalists (VCs) play an important role for public firm investment variation. Public firms increase 2.2% R&D investment one year after a one-standard-deviation increase in average investment amount received by VC-backed startups in the same industry. Relying on exogenous variation in CVC parent firm abnormal stock return, this finding is likely driven by causality. This effect is more pronounced for public firms with smaller size, smaller marker share, lower profitability, more growth uncertainty, more innovation and more cash holdings, pointing to rational herding, informational learning, technology spillover and product market competition as potential motivations. Furthermore, the investment relevance is driven by a leader-follower model in which public firms are sensitive to VC investment decision but not vice versa. By documenting the effect of VC investment on public firm R&D investment decision, this paper sheds light on future work of better understanding the influence of the private market on the public market.

Keywords: Venture capitalist, Public firm, R&D investment

1. Introduction

Do public firms learn valuable information and investment opportunities from participants in the private market? This is an important question. Although existing strands of literature have well documented that public firm managers learn growth opportunities from peers' behavior, and use this information to guide their investment and capital structure decision (e.g., Foucault and Fresard, 2014; Leary and Roberts, 2014), these studies largely ignore the question whether public firms learn from the private market and its participants, such as startups and venture capitalists (VCs). On one hand, public firms are more mature and tend to have more standardized daily operations, more stable internal structure, clearer long-term business plans, stronger ties with their business partners, and thus may have less incentives to learn from smaller firms and venture capitalists. On the other hand, venture capitalists, as an important driver of technological innovation, invest in and create value for entrepreneurial firms. Startups funded by VCs are more innovative, and have a higher level of productivity (Alon and Gompers, 1997; Tian and Wang, 2014). The investment behavior of VCs releases information of growth opportunity, which may be valuable to the public firms. In this paper, I fill the gap in the existing literature by exploring whether public firms learn from VC investment when they make R&D investment.

To shed light on the intuition and ease the discussion, consider such a situation that managers of public firms are unsure about how to set the optimal investment level, because optimization is time-consuming and costly. As such, they may consider VC investment received by startups in their industry as informative. For instance, when VCs decide to provide a new round of funding to startups, the total investment received by startups is higher than it would be if the new investment decision has not been made. The managers may attribute such increase in total investment level to additional growth opportunities that VCs have identified. They may thus follow the VCs, and increase R&D investment to pursue these new opportunities.

I hypothesize that public firm R&D investment is positively associated with VC investment, generated by four potential motivations. First, rational herding. When optimization is time-consuming or costly, herding behavior will be rewarded, even though it is suboptimal, because it avoids the optimization cost (Conlisk, 1980; Banerjee, 1992). Learning from VC investment certainly falls into this category, because VCs invest in entrepreneurial firms to identify new emerging technologies (MacMillan et al., 2008; Ma, 2015). Second, informational learning. VCs' investment behavior may release information to the market, the information that may complement public firm managers' knowledge of growth opportunities. The managers then update their priors in Bayesian manner (Bikhchandani et al., 1998; Devenow and Welch, 1996), and use them to guide the investment decision. Third, technology spillovers. Startups funded by VCs are more innovative, and have a higher level of productivity (Alon and Gompers, 1997; Tian and Wang, 2014). VC-backed startups identify new ideas and develop technologies, and these technologies may be diffused, resulting in an increase in R&D investment for further exploration. Fourth, product market competition. VCs supervise and monitor their portfolio startups (Barry et al., 1990; Lerner 1995), help the startups develop new products and explore new markets (MacMillan et al., 2008), improve their efficiency and profession (Hellmann and Puri, 2002), and thus bring potential product market competition. This potential competition may encourage R&D investment of existing firms (Aghion and Howitt, 1992; Caballero and Jaffe, 1993; Aghion et al., 2005). Hence, I postulate that VC investment positively affects public firm R&D investment.

Using 23,995 firm-year observations of 2,484 public firms between 1980 and 2015, I show that, controlling for firm-specific characteristics, public firm R&D investment increases 2.2% one year after a one-standard-deviation increase in average investment amount received by VC-backed startups. This effect is long lasting and accumulative. An endogenous concern may arise when VC investment is a function of public firm investment, or there exist omitted variables that simultaneously affect both public firm and VC investment. To establish a causal relation, I consider the CVC setting, and design an event study approach which relies on abnormal stock return of CVC parent firms. CVCs are the subsidiaries of corporations (called as parent firms), acting as the venture arms and investing in new ventures on behalf of the parent firms. In 2015, CVC investment accounts for around 20% of all VC investment, recorded by National Venture Capital Association.

CVC parent firm stock return impounds many value-relevant events of the firm and its CVC arm, such as accounting scandals, accidental economic events and natural disasters. In the meanwhile, stock return plays an important role in determining capital structure and investment (Myers and Majluf, 1984; Baker and Wurgler, 2002; Welch, 2004; Foucault and Fresard, 2014). Using CVC parent firm abnormal return as instrument variable for CVC-backed startup average funding amount helps mitigate the endogenous concern and establish a causal relation between VC investment in startups and public firm R&D investment. To isolate the idiosyncratic variation in stock return of CVC parent firms, I use the augmented market model, which incorporates both the market factor and the industry factor. The residual from estimating this model is defined as abnormal return. Abnormal return is serially uncorrelated, cross-uncorrelated and serially cross-uncorrelated, suggesting that little common variation exists between public firms' and CVC parent firms' abnormal return.

Our CVC setting has another advantage. Although VentureXpert and other databases provide detailed information of VC financing on startups, accounting data of VCs or startups is not available. As financial characteristics are important determinants of investment decision, the absence of such variables may be problematic. Under our CVC setting, the availability of accounting and financial data of CVC parent firms helps overcome this challenge.

The reduced form results show that firm's R&D investment is significantly positively associated with CVC parent firm average abnormal return. For each firm *i* in industry *m*, CVC parent firm averages are measured by weighted-averages of all CVC parent firms, who invest in startups in industry *m*, within an industry-year combination. The abnormal return of CVC parent firms affects public firm R&D investment in a similar manner as firms' own abnormal return, by reflecting growth and investing opportunities. I then use CVC parent firm average abnormal return as instrument variable for CVC-backed startup average funding amount and implement the two-stage least squares (2SLS) analysis. Evidence shows that public firms increase their R&D investment by 17.7%, on average, in the year following a one-standard-deviation increase in CVC-backed startup average funding amount. These results support the hypothesis that CVCs play a significant role for public firm investment variation.

To mitigate the concern that the relation between CVC investment and public firm R&D investment is caused by the peer effect between CVC parent firm and public firms, I undertake four robustness analysis. First, I include industry average abnormal return and characteristic variables. The results hold. Second, I exclude the CVC parent firms which themselves are also in industry *m* from the CVC group. I continue to observe similar results. Third, I exclude the CVC parent firms whose industries have business relationship with the public firm's industry. My findings continue to hold. Fourth, I restrict the CVC parent firms as the firms having their first round of financing in the public firm's industry. The results are robust.

I then conduct a number of robustness tests to eliminate the concern caused by omitted variables. First, I replace public firm-specific abnormal return with contemporaneous and lead-one-year stock return to eliminate the concern of common effect caused by asset pricing model misspecification. The results are robust. Second, I replace the characteristic control variables with the lead-one-year ones to control for the plausible effect of fundamental-related shocks. My findings continue to hold. Third, I restrict the sample to the public firms in 23 industries, the startups in which receive 90% of VC investment. I observe similar results.

To shed light on the underlying mechanisms through which CVCs affect public firm investment, I explore whether the sensitivity to CVCs exhibits cross-sectional heterogeneity along a number of firm characteristics. Firm's R&D investment sensitivity to CVCs is higher among firms with smaller size, smaller marker share, lower profitability, more growth uncertainty, more innovation and more cash holdings, which have more incentives to learn additional growth opportunities from CVCs or have higher ability to pursue these opportunities. This cross-sectional evidence suggestively points to rational herding, informational learning, technology spillover and product market competition as potential motivations of public firms' mimicking behavior. These results also reinforce my identification strategy since other hypotheses have little room for the heterogeneity along firm characteristics on CVCs' influence.

In the final part of this paper, I explore whether CVCs follow each other or the public firms. I find no statistically significant evidence of the mimicking behavior of CVCs, i.e. CVCs do not follow each other or the public firms. The investment relevance is driven by a leader-follower model in which public firm investment is sensitive to CVC investment but not vice versa.

This paper contributes to two strands of literature. First, this paper adds to the venture capital literature, which documents the influence of venture capitalists. These studies mainly focus on examining the role VCs play for the entrepreneurial firms. Specifically, VCs create value for the startups by intensive monitoring, reputation, improved efficiency, professionalization, industry expertise, staged investment structure, syndication, market timing ability, tolerance for failure, and network positions (e.g., Megginson and Weiss, 1991; Lerner, 1994b; Alon and Gompers, 1997; Chemmanur et al., 2011; Tian and Wang, 2014). VC-backed startups have better incubation outcome and better IPO and post-IPO performance (Da Rin, Hellmann, and Puri (2013) conduct an excellent survey of the literature). However, these studies have largely ignored the influence of VCs on the public market. This paper attempts to fill in this gap by providing evidence that links VC investment and public firm R&D investment.

Second, this paper is closely related to the literature documenting firm investment determinants. Existing literature has identified stock returns, cash flow, Tobin's *Q*, and other financial variables (e.g., Hayashi, 1982; Myers and Majluf, 1984; Poterba, 1988; Erickson and Whited, 2000; Baker and Wurgler, 2002; Alti, 2003; Welch, 2004) as important determinants of investment decision. Some studies further show that firms' investment is associated with peer firm investment in the same industry or other firms headquartered nearby (Foucault and Fresard, 2014; Dougal et al., 2015). This paper adds to this literature by showing that public firms' investment is highly sensitive to VC investment in the same industry.

The rest of the paper is organized as follows. Section 2 reports sample selection and summary statistics. Section 3 describes empirical methodology, preliminary results and identification strategy. Section 4 presents the main results and robustness checks. Section 5 discusses the potential mechanisms and heterogeneous effect. Section 6 discusses the leader-follower model. Section 7 concludes.

2. Data and Main Variables

2.1 Corporate Venture Capitalists

Corporate venture capitalists are the subsidiaries of corporates, acting as the venture arms and investing in startups on behalf of the corporates. To identify CVCs and their parent firms, I start with a list of venture capitalists classified as Corporate PE/Venture in the VentureXpert database. The VentureXpert identifies 874 CVCs in the United States, investing in 9,970 U.S. startups during 1980 to 2015. Using various information sources (e.g., Bloomberg, Google), I exclude the CVCs with multiple parent corporates, foreign or unknown parent corporates or financial parent corporates (SIC between 2000 and 2999). This leaves us distinct 451 CVCs that are affiliated with a unique U.S publicly traded parent corporate, which is listed in both the Compustat and the CRSP databases.

2.2 Startups

The information about the date, investment amount, and list of investing VCs of each round of financing is retrieved from VentureXpert. I identify 36,305 nonfinancial and nonutility (SIC between 4900 and 4999) startups that receive VC investment during 1980 to 2015, and define them as VC-backed startups. 5,418 of them receive investment from at least one of the CVCs in our sample. These startups are defined as CVC-backed startups.

For each startup, I mark its exit status as going public through initial public offerings (IPO), being merged or acquired (M&A), being written-off, or being under active incubation. I retrieve information about IPO deals and M&A deals that are related to our sample startups from the Global New Issues database and the Mergers and Acquisitions database on SDC Platinum, respectively. If an IPO deal happens after the first round of VC financing, it is classified as an IPO exit deal. If a completed M&A deal targets a startup after the first round of financing, and involves no less than 50% of all shares, it is classified as a M&A exit deal. If a startup is involved in more than one M&A exit deal and/or IPO exit deal, it is considered to be exiting through the earliest one. If a startup does not receive any VC financing within three years after its recorded last round of financing, it is considered to be written off. If a startup does not exit through IPO, M&A or being written off, it is considered to be under active incubation.

Table 1 Panel A presents the summary statistics for the characteristics of startups in our sample at startup level. A typical VC-backed startup in our sample receives 26.72 million dollars of investment from 2.68 VCs during 5.49 years' incubation. A typical CVC-backed startup receives 61.48 million dollars of investment from 1.71 CVCs during 7.20 years' incubation.

2.3 Public Firms

The financial and accounting data of CVC parent firms and other public firms between 1980 and 2015 comes from the Compustat database. I follow existing literature and construct R&D investment variable and other seven characteristics variables, including firm size, cash holdings, Tobin's Q, profitability, tangibility, debt issuance, and equity issuance. I relegate the variable definition to Appendix A. To ensure consistency throughout the analysis, only observations with no missing information on R&D investment or other control variables are included, and at least three years of nonmissing data is required. I also exclude financial firms, utilities firms and government entities (SIC greater than or equal to 9000) from the sample.

Table 1 Panel B presents the summary statistics for my final sample of 23,995 firm-year observations corresponding to 2,484 (non-CVC parent) public firms. A typical firm in our sample has R&D investment (ratio) of 0.09, firm size of 4.52, cash holding (ratio) of 0.21, Tobin's Q of 1.88, profitability (ratio) of 0.04, tangibility (ratio) of 0.23, debt issuance of 0.03, and debt issuance of 0.08.

For each public firm *i* in industry *m*, I construct industry averages as the averages of all firms, excluding firm *i*, within an industry-year combination. Industry groups are defined by three-digit SIC code. At least one CVC-backed startup in the industry group is required. It ends up with 83 industries represented in our sample. A typical industry contains 29.93 firms.

I construct CVC parent firm averages as the weighted-averages of all CVC parent firms, who invest in startups in industry *m*, through their CVC arms, within an industry-year combination. Specifically, I first calculate, for startup *j* in industry *m*, the averages of CVC parent firms, who invest in it. I then calculate, for industry *m*, the averages of the averages of startups in this industry.

For example, if industry *m* has only two *startups* A and B. None of them receives VC funding before 1980 and after 1985. *CVC parent firms* E, F and G invest in these two startups through venture arm *CVC* e, f and g, respectively. In 1980, *startup* A receives funding from *CVC* e, and *startup* B receives funding from a non-CVC. In 1981, *startup* B receives funding from *CVC* f. In 1982, *startup* B receives funding from *CVC* g. In 1983, *startup* B exits. In 1984, *startup* A exits.

The followings are the measures of CVC parent firm averages for all public firms in industry *m*: $\bar{X}^m_{1980} = X^m_{E,1980}$, $\bar{X}^m_{1981} = \frac{1}{2}(X^m_{E,1981} + X^m_{F,1981})$, $\bar{X}^m_{1982} = \frac{1}{2}(X^m_{E,1982} + \frac{1}{2}(X^m_{F,1982} + X^m_{G,1982}))$, $\bar{X}^m_{1983} = \frac{1}{2}(X^m_{E,1983} + \frac{1}{2}(X^m_{F,1983} + X^m_{G,1983}))$, and $\bar{X}^m_{1984} = X^m_{E,1984}$. CVC parent firm averages before 1980 and since 1985 are missing.

The summary statistics of industry averages and CVC parent firm averages are presented in Table 1 Panel C. All variables are winsorized at the 1st and 99th percentiles to minimize the effect of outliers.

3. Preliminary Results and Identification Design

In this section, I present the empirical methodology, preliminary results and identification attempt. Specifically, the empirical baseline model and preliminary results are presented in Section 3.1. Identification strategy design is discussed in Section 3.2. The construction of instrumental variable, abnormal return, is reported in Section 3.3.

3.1 Empirical Methodology and Preliminary results

To estimate the covariation between public firm R&D investment and VC investment, I begin with the following baseline regression model.

$$RD_{i,m,t+1} = \alpha + \beta' \times \overline{INV}_t^m + \delta' \times X_{i,m,t} + FE_t + \varepsilon_{i,m,t+1} \quad (1)$$

where *i* indexes firm, *m* indexes industry, and *t* indexes year. The unit of observation is firm-year. The dependent variables ($RD_{i,m,t+1}$) denotes R&D investment of firm *i* in industry *m* at period *t*+1. The covariate $\overline{INV}_t^m$ is a measure of average funding amount received by VC-backed startups in industry *m* at period *t*. The influence of VC investment on firms' R&D investment is captured by β'. Firm-specific vector ($X_{i,m,t}$) of control variables, including firm size, cash holdings, Tobin's Q, profitability and tangibility, is also included. Year fixed effect is included to remove time-series variation. To correct for potential heteroscedasticity, I adjust standard errors at firm level.

All variables are normalized by their sample standard deviation to facilitate the interpretation of economic magnitudes. Each coefficient can be interpreted as the change in public firm R&D investment (as a proportion change of its standard deviation) associated with one-standard-deviation change in the corresponding independent variable.

I estimate equation (1) with ordinary least squares (OLS) regression model and report results in Table 2 Panel A. Column (1) reports the results of regression using VC-backed startup average funding amount as independent variable. The coefficient estimate on VC-backed startup average funding amount is positive and significant at the 1% level, suggesting that firm's R&D investment increases significantly one year after an increase in VC investment in startups. In column (2), I include firm-specific control variables. The significantly positive effect of VC-backed startup average funding amount on public firm R&D investment holds. The economy effect is sizable: a one-standard-deviation increase in VC-backed startup average funding amount is associated with 2.2% increase in public firm R&D investment in the following year. In column (3) and (4), I replace the dependent variable with public firm R&D investment at *t*+2 and at *t*+3, respectively. The coefficient estimates of VC-backed startup average funding amount are significantly positive. The magnitude in column (4) is about 50% higher than in column (3) and 100% higher than in column (2), suggesting that the effect of VC investment on public firm R&D investment is long-lasting and accumulative.

An endogenous concern may arise as we use $\overline{INV}_t^m$ as independent variable in equation (1). If VC investment is a function of public firm investment, or there exist omitted variables that affect both public firm investment and VC investment, $\overline{INV}_t^m$ is then an endogenous variable, and the parameter estimated by equation (1) would be misleading. Further identification strategy is needed.

Besides, although VentureXpert and other databases provide detailed information of VC financing on startups, accounting data of VCs or startups is not available. As financial characteristics are important determinants of investment decision, the absence of controlling such variables may be problematic.

3.2 Identification Strategy

To establish a causal relation between VC investment and public firm R&D investment, I consider an event study approach. To identify events that are relevant with public firm investment decision but that are random with respect to VC investment, I consider the CVC setting and begin with the abnormal stock return of CVC parent firms.

CVC parent firm stock return impounds many value-relevant events of the firm and its CVC arm, such as accounting scandals, accidental economic events and natural disasters. In the meanwhile, stock return plays an important role in determining capital structure and investment (Myers and Majluf, 1984; Baker and Wurgler, 2002; Welch, 2004; Foucault and Fresard, 2014). Using CVC parent firm abnormal return as instrument variable for CVC-backed startup average funding amount helps mitigate the endogenous concern and establish a causal correlation between VC investment in startups and public firm R&D investment.

To isolate the idiosyncratic variation in stock return of CVC parent firms, I use traditional asset pricing model, the augmented market model, which incorporates both the market factor and the industry factor, to purge the market variation and industry variation, respectively. The residual from estimating this model is the idiosyncratic component and is defined as abnormal return.

The abnormal return is serially uncorrelated, cross-uncorrelated and serially cross-uncorrelated, suggesting that little common variation exists between public firms' and CVC parent firms' abnormal return. This property also suggests that CVC abnormal return are not able to affect public firm abnormal return in the current period, or to predict any future abnormal return for themselves or for public firms. I then use the abnormal return as exogenous instrumental variable for the CVC parent firm investment to mitigate the endogenous concern.

While vast existing papers in asset pricing literature support this identification approach, one of the main concerns of this approach comes from its reliance on the accuracy of the asset pricing model. If the model fails to fully explain the relationship between return and risk, and inaccurately predict the expected return, my measure of abnormal return as the residual from the model might be misleading. I further discuss and mitigate this concern in Section 4.3.

The CVC setting has another advantage: The availability of accounting and financial data of CVC parent firms helps overcome the challenge caused by the absence of VC financial data. Controlling CVC parent firm financial variables, including firm size, cash holdings, Tobin's *Q*, profitability and tangibility, helps control the plausible effect of the shared characteristics between VCs and public firms on public firm R&D investment behavior.

I re-estimate equation (1) under CVC setting, using CVC-backed startup average funding amount as dependent variable to estimate the effect of CVC investment on public firm R&D investment. The results are presented in Table 2 Panel B. The coefficient estimates of CVC-backed startup average funding amount are significantly positive at 1% level for each column, suggesting the positive effect of CVC investment on public firm R&D investment, although the magnitude is lower than the magnitude of coefficients in Panel A. The magnitude of coefficient estimate of CVC-backed startup average funding amount in column (3) is higher than the magnitude in column (2), and the magnitude in column (4) is higher than the magnitude in column (2), suggesting that the effect of CVC investment on public firm R&D investment is long lasting and accumulative. These findings support our focus on CVC setting.

3.3 Abnormal Return

To measure abnormal return, I start with estimating expected stock return by augmented market model, following Leary and Roberts (2014).

$$R_{i,m,t} = \alpha_{i,m,t} + \beta_{i,m,t}^{M} \times \left(R_t^M - R_t^f\right) + \beta_{i,m,t}^{IND} \times \left(R_{-i,m,t}^{IND} - R_t^f\right) + \varepsilon_{i,m,t} \qquad (2)$$

where *i* indexes firm, *m* indexes industry, and *t* indexes month. The unit of observations is firm-month. $R_{i,m,t}$ refers to the stock return of firm *i* in industry *m* at period *t*. R_t^M refers to the equally-weighted market return. R_t^f refers to the risk-free rate. $R_{-i,m,t}^{IND}$ refers to the industry return, which is measured by the equally-weighted averages of all firms in industry *m* at period *t*, excluding firm *i*. As in measuring industry average control variables, industry groups are defined by 3-digit SIC code. The excess market return factor ($R_t^M - R_t^f$) and excess industry return factor ($R_{-i,m,t}^{IND} - R_t^f$) are incorporated to purge the common variation among all firms in the market and among peer firms in the same industry, respectively. $\beta_{i,m,t}^{M}$ and $\beta_{i,m,t}^{IND}$ capture the correlation between firm stock return and these two excess return, respectively. Abnormal return is measured by the residual term $\varepsilon_{i,m,t}$.

I estimate equation (2) for each sample public firm and CVC parent firm in each year on a rolling annual basis. For year *t*, I use the historical monthly stock return data during year *t*-5 to *t*-1 to estimate the coefficients $\hat{\beta}_{i,m,t}^{M}$ and $\hat{\beta}_{i,m,t}^{IND}$, and the interaction term $\hat{\alpha}_{i,m,t}$. I then combine them with the historical market excess return and historical industry excess return of each month in year *t* to estimate the expected stock return for each month in year *t*. The difference between realized return and expected return is the abnormal return. For year *t*+1, I do the same estimation by using the monthly stock return data during year *t*-4 to *t* to estimate coefficients and expected return in year *t*+1. At least 24 months of sample is required.

$$\text{Expected return } \ \hat{R}_{i,m,t} = \hat{\alpha}_{i,m,t} + \hat{\beta}_{i,m,t}^{M} \times \left(R_t^M - R_t^f\right) + \hat{\beta}_{i,m,t}^{IND} \times \left(R_{-i,m,t}^{IND} - R_t^f\right)$$

$$\text{Abnormal return } \ \hat{\varepsilon}_{i,m,t} = \hat{R}_{i,m,t} - R_{i,m,t}$$

The monthly stock return data comes from the Center for Research in Security Price (CRSP) database. For consistency with the accounting data, I use the annual abnormal return, which is measured by compounding the monthly abnormal return. For each firm *i* in industry *m*, I construct industry average abnormal return as the averages of all firms, excluding firm *i*, within an industry-year combination. I also construct CVC parent firm average abnormal return as the weighted-averages of all CVC parent firms, who invest in startups in industry *m*, within an industry-year combination. Table 1 Panel D reports the summary statistics of annual stock return and abnormal return, as well as industry averages and CVC averages. A typical firm has compounded annual stock return of 0.16, abnormal return of -0.10, industry average abnormal return of -0.10, and CVC parent firm average abnormal return of -0.07.

4. Do Firms Follow Venture Capitalists?

In this section, I present the main findings on causal relation between CVC investment and public firm R&D investment. In Section 4.1, I report reduced-form results by using CVC parent firm average abnormal return as key independent variable. I then conduct four robustness checks to eliminate the potential industry peer effect between CVC parent firms and public firms, and report the results in Section 4.2. More robustness checks with omitted factors are presented in Section 4.3. In Section 4.4, I use CVC parent firm average abnormal return as instrument variable

(IV) for CVC-backed startup average funding amount, and use the two-stage least squares (2SLS) approach to estimate the role CVCs play in determining public firm R&D investment.

4.1 Reduced-Form Results

In reduced-form estimation, I replace CVC-backed startup average funding amount ($\overline{INV}_{t-1}^{m}$) with its instrumental variable, CVC parent firm average abnormal return, as key independent variable, and use ordinary least squares (OLS) regression model to estimate equation (1). I also include firm-specific abnormal return. Control variables include CVC parent firm average and firm-specific firm size, cash holdings, Tobin's *Q*, profitability and tangibility. Year fixed effect is included. Standard errors are clustered at firm level. Dependent variables lead independent variables one year. To have a better understanding on how public firms react to CVC investment, public firms in the sample are required to be non-CVC parent firms.

Results are presented in Table 3. Column (1) reports the results of regression using CVC parent firm average abnormal return as independent variable. The coefficient estimate on CVC parent firm average abnormal return is positive and significant at the 1% level, suggesting that public firm R&D investment increases significantly one year after an increase in CVC parent firm average abnormal return. In column (2), I add CVC parent firm average control variables. The coefficient estimate on CVC parent firm average abnormal return remains significantly positive at 1% level. Regarding CVC average characteristics, public firm's R&D investment is significantly negatively correlated with CVC average firm size, cash holdings and tangibility, and positively correlated with Tobin's *Q*. These findings suggest that another channel, through which CVC parent firms may influence public firms' investment decision, is via characteristics.

Column (3) reports the results of regression using both firm-specific and CVC parent firm average factors as independent variables. The results reveal that firm's own abnormal return is strongly positively associated to R&D investment. Consistent with the existing literature (e.g. Chen et al., 2007; Bakke and Whited, 2010), this finding is a suggestive evidence that equity price complements managers' knowledge about their firms' growth opportunities, and guides their investment behavior. The same positive sign of CVC parent firm average abnormal return suggests that the abnormal return of CVC parent firms affects public firms in a similar manner as firms' own abnormal return.

Regarding financial control variables, the coefficient estimates of firm's own cash holdings and Tobin's Q are significantly positive at 1% level, and coefficient estimates of profitability and tangibility are significantly negative at 1% level. The significant effect of firm's fundamentals on investment prospects supports the argument that financing and accounting characteristics are important determinants of investment decision, and firm's stock price may not be a sufficient statistic for explaining the decision (Hayashi, 1982; Erickson and Whited, 2000).

The results reported in Table 3 suggest that when making R&D investment decision, public firms incorporate information reflected by the abnormal return of CVC parent firms who invest in the same industry. CVCs have significant influence on public firm investment variation. The abnormal return of CVC parent firms affects public firm investment decision in the similar manner as firm's own abnormal return.

4.2 Robustness Checks with Peer Effect between CVC Parent Firms and Public Firms

The findings in the last section suggest that public firm R&D investment is positively affected by CVC parent firms abnormal return. Before moving on to estimate the structural effects, I eliminate the other plausible explanations for this causal correlation in this section.

To ease the discussion, consider *public firm* A and *CVC parent firm* B, who invests in *startup* C though its CVC arm. All of them are in the same industry. Broadly, the interaction between A and B may covary though either $A \rightarrow B$ or $B \rightarrow A$. The evidence in the last section supports the latter channel by using CVC parent firm's idiosyncratic term of stock return as the key variable. Considering the presence of relationship between CVC parent firm B and its startup C, this causal relationship can not only be $B \rightarrow A$ but also be $B \rightarrow C \rightarrow A$.

The former relationship has been well documented by previous studies (Foucault and Fresard, 2014; Leary and Roberts, 2014). These studies find that peer effect plays an important role when firms make decision of investment, leverage ratios and security issuance. The goal of this paper is to explore the latter channel, the influence of CVCs on public firms' investment expenditures, through their investment in startups. The difference between these channels is crucial for understanding the role that CVCs and their parent firms play for the public firms.

In empirical, since sourcing new technologies and rating the acquiring potential are prominent motives of investment in startups through CVC arms (Siegel et al., 1988; Hellmann, 2002; MacMillan et al., 2008), it is very likely that CVC parent firms invest in startups in the same industry with themselves. If this is the case, the potential for peer effect explanation arises. In this section, I design four robustness tests to eliminate the possibility of this explanation for our baseline results.

4.2.1 Controlling Industry averages

First, I augment the baseline specification with industry average abnormal return and control variables to control for the industry peer effect. To save space, I only report the coefficients of the industry average variables, and CVC parent firm average and firm specific abnormal return. The results, presented in Table 4 column (1), show that CVC parent firm average abnormal return remains a significant predictor of public firm R&D investment decision. Industry average abnormal return is not significantly correlated to firms' R&D investment. The significant coefficients of industry average firm size, cash holdings, Tobin's *Q* profitability and tangibility suggest the presence of peer effect on public firm R&D investment.

4.2.2 Peer effect in the same industry

To further address the concern, I then exclude the CVC parent firms which themselves are also in industry *m* from the CVC group for public firms in industry *m*. That is, I use the weighted-averages of all CVC parent firms, who themselves are not in but invest in startups in industry *m*, within an industry-year combination as the measure of CVC parent firm averages. I include the CVC parent firm averages, industry averages and firm-specific factors in equation (1) and report the estimation results in Table 4 column (2). The results show that the positive relationship between CVC average abnormal return and firm R&D investment remains statistically significant at 1% level, and the magnitude also holds.

4.2.3 Peer effect through business relationship

The concern still remains if the CVC parent firm's industry and startup' industry *m* have business relationship. For example, if the startup' industry *m* is an important consumer of the products manufactured by CVC parent firm's industry, a positive shock to industry *m* might also cause a positive abnormal return to CVC parent firm. If this is the case, the positive relation between public firms in industry *m* and CVC parent firm average abnormal return is not driven by causality, but by the shock to industry *m*. To eliminate this concern, I exclude all the CVC parent firms that have business relationship with the public firm.

To measure the business relationship between two industries, I use the Benchmark Input-Output (I-O) data provided by the Bureau of Economic Analysis (BEA). "Use" table contains information about dollar amount of goods and services that are consumed by final users. I use the data from this table to quantify the proportion of industry *i*'s total output that is contributed by industry *j*. I then quantify the proportion of industry *i*'s input for production that is manufactured by industry *j*, using data from the Supplementary Industry-by-Commodity Total Requirements table. If both the output proportion and the input proportion are less than 1%, two industries are considered not having business relationship.

BEA publishes a set of I-O data files every five year since 1982, and every year since 1997. To measure business relationship among industries between 1980 and 2015, I apply the measured relationship in 1982 as the proxy for the relationship during 1980 to 1984, the one in 1987 for the relationship during 1985 to 1989, the one in 1992 for the relationship during 1990 to 1994, the one in 1997 for the relationship in 1995 and 1996, and use the annual measured relationship between 1997 and 2015. I use I-O industry codes (1992, 1987 and 1992) and NAICS codes (between 1997 and 2015) to identify industries. I merge the data and construct annual relationship with the 3-digit SIC code identifications. If multiple I-O industry codes or NAICS codes are concord to the same 3-digit SIC code, I take the arithmetic average.

I use the weighted-averages of all CVC parent firms, whose industries do not have business relationship with but invest in industry *m*, within an industry-year combination as the measure of CVC parent firm averages. The sample size shrinks to 7,257. Results, presented in Table 5 column (3), show that the coefficient estimate of CVC parent firm average abnormal return remains statistically significant at 1% level, and the magnitude is even higher than the one in column (1).

4.2.4 Returns from holding the startups

The last concern comes from the plausibility that CVC parent firm abnormal return is related the return from the investment in startups. If there is a positive shock to the startup's industry *m*, it might cause the increase of R&D investment of the public firms in the same industry, as well as the valuation of the startup, bringing positive abnormal return to its CVC parent firms. If this is the case, the positive relation between public firms in industry *m* and CVC parent firm average abnormal return might not be causal. To eliminate this concern, I exclude all the CVC parent firms that have position on startups in industry *m* in the previous year. That is, I use the weighted-averages of all CVC parent firms, who invest their first round of financing in industry *m*, within an industry-year combination as the measure of CVC parent firm averages. The results, presented in Table 4 column (4), show that CVC parent firm average abnormal return remains a significant predictor of public firm R&D investment choices.

In summary, the fact that the explanatory power of CVC parent firm average abnormal return is not absorbed after controlling the potential peer effects between CVC parent firms and public firms is a suggestive evidence that the influence of CVC investment behavior on public firm R&D investment decision cannot be fully explained by the peer effect. The results of these tests not only strengthen the robustness of CVC's influence on public firm R&D investment, but also suggest that CVC investment contains additional information, that are not reflected by industry or public firm-specific characteristics and investment actions.

4.3 Robustness Checks with Omitted Factors

The baseline results also face the concerns about the extent to which the measure of CVC abnormal return may be correlated with omitted and unobservable factors, and the extent to which, as I discuss in Section 3.3, I have removed the common market variation and industry variation from stock returns via the asset pricing model. In this section, I mitigate these concerns and reduce the identifying variation by introducing additional control variables to capture the plausibly under-estimated common factors. To save space, I only report the coefficients of the additional variables, and of CVC parent firm average and firm specific abnormal return. To control the potential peer effect, since this session, we use the measurement of CVC averages as in session 4.2.2: CVC averages are measured by the weighted-averages of all CVC parent firms, who themselves are not in but invest in startups in industry *m*. CVC averages, industry averages and firm specific abnormal return and controls are included. So is year fixed effect.

4.3.1 Misspecification of asset pricing model

The first concern comes from the possibility of asset pricing model misspecification, resulting in that common factors may still remain in the abnormal return, the estimated idiosyncratic component of stock return. To mitigate this concern, I replace the firm-specific abnormal return with contemporaneous and lead-one-year stock returns. Because stock returns, compared to the idiosyncratic components, are arguably better capturing the common factors. By adding the stock return factors, I also control for the potential asynchrony in shocks to equity valuation, and eliminate the concern caused by the fact that some firms may be affected by shocks in their equity valuation earlier than others. The results, presented in Table 5 column (2), show that the coefficient of CVC parent firm average abnormal return remains significantly positive at 1% level, and the economic magnitude holds.

These findings mitigate the concern that the influence of CVCs on public firm investment decision may be explained by some common factors that have not been captured by the asset pricing model.

4.3.2 Shocks to firm characteristics

The second concern comes from the additional shocks to firm characteristics and capital structure in *t*+1, which might affect firm's investment decision, but not be captured by the control variables in *t*. To mitigate this concern, I replace CVC parent firm average and firm-specific control variables with lead-one-year CVC parent firm average and firm-specific controls to estimate equation (1). Results, reported in Table 5 column (3) show that the significant effect of CVC parent firm average abnormal return remains, although the magnitude decreases.

4.3.3 Investment distribution among industries

The third concern comes from the investment distribution inequality among industries. In our sample, 90% of VC investment is received by startups in 28 industries. While the findings in the previous sessions use all sample public firms in 81 industries and show that CVC parent firm average abnormal return is a significant predictor of public firm R&D investment decision, it would be important to estimate the effect with restricted sample to these 28 industries. The results, presented in Table 5 column (4), show that the coefficient of CVC parent firm average abnormal return remains significantly positive at 1% level, and the economic magnitude is higher.

4.4 Structural Estimates

In this section, I estimate the influence of CVC investment on public firm R&D investment decision. Specifically, I use CVC parent firm average abnormal return as instrumental variable for

CVC-backed startup average funding amount, and estimate equation (1) via two stage least square model (2SLS).

To conduct the 2SLS model, a significant relevance condition between CVC parent firm average abnormal return and its instrument, CVC parent firm average abnormal return, is required. I first test this requirement by estimating with CVC parent firm average abnormal return as dependent variable and CVC parent firm average abnormal return as key independent variable. Results are reported in Table 6 Panel A column (1). All other variables and settings are the same as the ones used in Section 4.2.2.

First-stage results reveal that CVC parent firm average abnormal return is significantly positively correlated with CVC-backed startup average funding amount. These results are consistent with previous findings that relate stock return and total return to investment and growth opportunities. The F-statistic, Cragg-Donald Wald F-statistic and SW Chi-sq-statistic suggest the instrument variable, CVC parent firm average abnormal return, passes the weak instrument test and under-identified instrument test.

I then use CVC parent firm average abnormal return as instrument variable for CVC-backed average funding amount, and use 2SLS model to estimate equation (1). Results are reported in Panel B column (1). CVC-backed average funding amount is significantly positively associated to public firms' R&D investment decision at 5% level. The economic magnitude is sizable: a one-standard-deviation increase in CVC-backed average funding amount is associated to 17.7% increase in public firm's R&D investment in the next year.

To better understanding the effect of CVC parent firm average abnormal return on their investment in startups in longer terms, I add average abnormal return in *t-1* and *t-2* as independent variable in each column in Panel C. The magnitude of coefficient of average abnormal return in *t-2* is larger than the magnitude in *t-1*, and the magnitude in *t-1* is larger than the magnitude in *t*. The F-statistic, Cragg-Donald Wald F-statistic and SW Chi-sq-statistic in column (1) are higher than the statistics in Panel A column (1), and the statistics in column (2) are higher than the statistics in column (1). These findings suggest the effect of CVC parent average abnormal return on their investment in startups is long lasting and is accumulative with time.

As shown in existing literature (e.g., MacMillan et al., 2008), both internal and external venturing are important for CVC parent firms. While they face outward to invest in startups to tap external source of new technologies, they face inward and interact with firm's R&D investment.

CVC parent firms' R&D investment complements their investment behavior, over and above that captured by investment in startups. Thus, I use CVC parent firm average R&D investment as the second key variable in estimating the influence of CVC investment on public firm R&D investment decision.

Results, presented in Table 6 Panel A column (2), show the significantly positive correlation between CVC parent firm average R&D investment and abnormal return. Results in Panel B column (2) show that the correlation between CVC parent firm average R&D investment and public firm R&D investment is positive and significant at 1% level. After CVC parent firms increase R&D investment by one-standard-deviation, on average, public firms increase R&D investment by 3.8% in the next year.

These results in this session suggest that public firms' R&D investment decision is affected by CVC parent firms' investment both in startups and in R&D, and is more sensitive to the former. The effects are statistically and economically large.

5. Why Do Firms Follow Venture Capitalists?

Given the causal relationship between CVC investment and public firm R&D investment, this section seeks to unravel why public firms mimic venture capitalists. I begin with a discussion of the potential motivates behind this mimicking behavior in Section 5.1. I then examine cross-sectional heterogeneity to shed lights on the underlying mechanisms in Section 5.2. I discuss other plausible mechanisms in Section 5.3.

5.1 Potential Motivates

There are several types of interactions between CVCs and public firms that are capable of generating the mimicking behavior of investment decision.

Rational herding might be one of the motivates. Banerjee (1992) suggests that decision rules may be characterized by herd behavior, i.e. doing what others do rather than using their own information. When optimization is time-consuming or costly, herding behavior, which avoids the optimization cost, will be rewarded, even though it is suboptimal (Conlisk, 1980). The investment behavior of VCs may be herded by public firms when they make R&D investment decision.

Such imitation behavior may also arise from informational learning. Foucault and Fresard (2014) and others suggest that managers learn additional growth opportunities from other firms.

The investment behavior of VCs may complement firm managers' knowledge of investing opportunities. Managers then update their priors in Bayesian manner (Bikhchandani et al., 1998; Devenow and Welch, 1996), and as a result, their investment decision will be pulled toward those of CVCs, relative to the decision they may have made if they rely only on their own information.

Technology spillovers might be another mechanism. Startups funded by VCs are more innovative, and have a higher level of productivity (Alon and Gompers, 1997; Tian and Wang, 2014). VC-backed startups identify new ideas and develop technologies, and these technologies may diffuse to other firms in the same industry, resulting in an increase in R&D investment for further exploration.

Potential product market competition brought by VC investment might also lead to the mimicking behavior. Venture capitals play an important role in the professionalization of startup firms (Hellmann and Puri, 2002). They supervise and monitor their portfolio entrepreneurial firms (Barry et al., 1990; Lerner 1995), help them develop new products and explore new markets (MacMillan et al., 2008), and thus bring potential competition to the existing industry. Schumpeterian literature suggests that the existence of future monopoly rents may induces firms to innovate (e.g., Aghion and Howitt, 1992; Caballero and Jaffe, 1993). Aghion et al. (2005) suggests that competition may foster firms' innovation and growth because they decrease the difference between preinnovation and postinnovation rents. The potential competition caused by VC investment falls in this category, and thus may encourage public firm R&D investment, which aimed at "escaping competition".

Although the mimicking behavior may arise for any of these reasons, these explanations are neither exhaustive nor mutually exclusive. For the most part, they cannot be distinguished from each other.

5.2 Cross-Sectional Heterogeneity

To shed light on the underlying mechanisms that may drive the mimicking behavior in investment, I explore heterogeneity by running cross-sectional tests in a few dimensions based on public firm characteristics, and examine whether some firms are more or less sensitive to CVC investment than others.

To avoid redundancy, I focus on how firms react to CVC parent firm abnormal return by using the reduced form framework in Section 4.2.2. I add interaction terms between CVC parent firm average abnormal return and firm characteristics variables in equation (1) to explore how these characteristics alter the influence of CVCs on public firm R&D investment.

5.2.1 Firm size

First, I explore the difference in mimicking behavior of large firms and small firms, a decomposition for two reasons. On one hand, I expect the rational herding and informational learning to be weaker for large firms, who are likely to have more informational advantage and lower cost of optimization. On the other hand, large firms are more likely to have cross-industry operations and sales forces, and therefore might be less affected by product market competition in one particular industry.

I add the interaction term between CVC parent firm average abnormal return and firm size into equation (1), and report the results in Table 7 column (1). To save space, I only report the coefficients of interaction terms and CVC parent firm average abnormal return. The coefficient estimate on the interaction term is negative and significant at the 1% level, suggesting that the positive effect of CVC parent firm abnormal return on public firm investment decision is mitigated for large firms. This finding is consistent with my conjecture that, because large firms have more informational advantage, lower cost of optimization, and more cross-industry operations, they are less likely to mimic the investment behavior of CVCs, compared to small firms.

5.2.2 Market share

I then replace firm size with market share (see Appendix A for definition) and investigate the difference in mimicking behavior between firms with large market share (leader firms) and others (follower firms). The intuition behind this decomposition is similar to the intuition behind firm size: while managers of follower firms have private information about their firms, managers of leader firms may have information that extend beyond their own firms. For example, the connected leader firms may hold meetings with each other to share important information and new ideas, which are not likely to be transmitted to the follower firms. Follower firms with information disadvantage need to explore other information resources, such as learning from CVC investment behavior.

Results in Table 7 column (2) show that the coefficient of the interaction term between market size and CVC average abnormal return is significantly negative, suggesting that the influence of CVCs is weaker for leader firms. This result is consistent with my conjecture that because of information disadvantage, it is more likely for follower firms to obtain information and learn from CVCs.

5.2.3 Profitability

Profitability may also play an important role in determining the coefficient of CVC parent firm abnormal return. Less profitable firms are more likely to be affected by the increase in product market competition. Increased competition in product market may drive down the prices, and bring loss, once the price is lower than the cost. If this is the case, CVC investment behavior might have stronger influence on the less profitable firms by bringing more potential product market competition through investing and incubating startups. Besides, it is plausible that less profitable firms have more incentives to grow by identifying new technology and exploring new product, and thus are more likely to obtain information from CVC investors as well as to herd their investment behavior.

Coefficient of interaction term between CVC parent firm average abnormal return and profitability, reported in Table 7 column (3), is negative and significantly at 1% level, suggesting that profitability weakens the influence of CVCs on firm investment decision, that is consistent with my conjecture. CVCs play a more important role in determining less profitable firm investment decision as these firms are more likely to be affected by the product market competition and have more incentive to learn from CVCs.

5.2.4 Growth uncertainty

Growth uncertainty may amplify CVCs' influence in a similar manner. Firms with higher growth uncertainty are more likely to affected by the increase in product market competition brought by CVC investment and have more incentives to herd this investment behavior. To capture growth uncertainty, I use the standard deviation of annual stock return in the current year and the last two years of all firms in the same industry. Results in Table 7 column (4) show that the coefficient term between CVC average abnormal return and growth uncertainty is significantly positively at 1% level. Consistent with my conjecture, growth uncertainty induces public firms to mimic CVC investment and thus amplifies the influence of CVCs on firms' R&D investment.

5.2.5 Innovation

Innovative firms invest in R&D, identify new technologies, and design new products. New technology plays an important role for them. If startups' technologies diffuse to the public market, more innovative firms might have more incentive to learn and pursue the innovation opportunities. Also, these firms might be more likely to have enough professionals and equipment to work on valuable projects. To test this conjecture, I construct innovation variable as the average of R&D investment of all firms in the same industry in the current year and the previous two years. I then use add the interaction term between innovation and CVC parent firm average abnormal return as key independent variable. Results are presented in Table 7 column (5). Coefficient estimate on the interaction term is positive and significant at 5% level, suggesting that more innovative firms are more influenced by CVC parent firm investment in startups. These results support the technology spillover mechanism conjecture.

5.2.6 Cash holdings

Cash holdings might affect the influence of CVCs. One of the conventional rationale for holding cash and other financial slack is that if firms have sufficient financial slack, they don't need to issue equity or debt when they want to pursue new valuable investing opportunities (Myers and Majluf, 1984). Without financial slack, managers may be forced to issue debt or equity with costs caused by undervaluation from the market. Therefore, firms with more financial slack is more likely to pursue additional investing opportunities learned from the CVCs, i.e. increase more R&D investment. On the other side, the cost of issuing debt or stock may force the firms without enough cash to give up some valuable projects.

I use cash holdings to proxy financial slack, and add the interaction term between firm cash holdings and CVC parent firm average abnormal return into equation (1). Results, presented in Table 7 column (6), show that the coefficient of the interaction term is positive and significant at 5% level, suggesting firms with more cash holdings increase more R&D investment after observing an increase in CVC parent firm abnormal return. Consistent with my conjecture, firms with more financial slack are more likely to be able to pursue the additional investing opportunities learned from CVCs, while firms without sufficient cash holdings are less likely to increase R&D investment to mimic CVCs.

In summary, the mimicking behavior is concentrated among firms with smaller size, smaller market share, lower profitability, more growth uncertainty, more innovation and more cash holdings, firms that have more incentives to learn additional investing opportunities from CVCs or have higher ability to pursue these opportunities. These results point to rational herding, informational learning, technology spillover and product market competition as potential motivations.

5.3 Other Plausible Mechanisms

In this section, I discuss other plausible mechanisms that might drive the influence of CVC investment on public firm R&D investment.

5.3.1 Irrational herding

Public firms' imitation behavior may arise from irrational herding. Because of the relationship between innovation and firm growth, innovation is one of the important determinants of firm market value. Thus, when firms observe VCs' investment in startups, they might follow the VCs and increase R&D investment to make them "look more innovative". If this is the case, the increase in R&D investment of these firms might aim at providing a positive signal to the market, rather than developing new technologies.

To test this conjecture, I focus on the sharp changes in R&D investment. For each firm-year observation, I construct two dummy variables, R&D sudden beginning dummy and R&D sharp increase dummy. If a firm has R&D investment in the current year but did not have R&D investment in the previous year, R&D sudden beginning dummy equals one, otherwise zero. If a firm's R&D growth is higher than 10%, R&D sharp increase dummy equals one, otherwise zero. I then use these two dummy variables as dependent variables and CVC average abnormal return as key independent variable to estimate equation (1).

Results are reported in Table 8 Panel A. Coefficient estimates on CVC average abnormal return are not statistically significant in both columns, suggesting that an increase in CVC average abnormal return does not followed by public firms' sharp changes in R&D investment. These results do not support the conjecture of irrational herding.

5.3.2 Liquidity from capital market

Capital market might be an important driver of public firms' imitation behavior. When VCs increase investment in startups, capital market may learn the existence of potential growth opportunities in the industry and thus be more willing to provide liquidity to the firms. The increase in liquidity may then drive the increase in R&D investment. To test this conjecture, I investigate whether public firms' debt issuance and equity issuance increase following after an increase in CVC parent firm average equity shock.

Results, presented in Table 8 Panel B1 column (1), show that the coefficient estimate on CVC average abnormal return is not statistically significant, suggesting that after an increase in CVC average abnormal return, public firms do not have significant increase in liquidity from bond market. Results in column (2) show that the coefficient estimate on CVC average abnormal return is positive and significant at 1% level, and a one-standard-deviation in CVC average abnormal return is followed by 1.8% increase in equity issuance in the next year. These results support the conjecture that liquidity from stock market increases through equity issuance following an increase in CVC parent firm average equity shock.

One challenge to this finding is that the increase in liquidity might be initiated by either the public firms or the capital market. To have better understanding on the underlying mechanism, I add the interaction term between cash holdings and CVC average abnormal return. Given the existence of issuance costs, firms with more cash holdings have less incentive to require liquidity from the market. If the public firms' incentives play a more important role in the increase in liquidity, one can expect the positive effect of CVC parent firm average abnormal return on equity issuance is less pronounced for firms with more cash holdings.

Coefficient estimate on the interaction term in Table 8 Panel B2 column (2) is significantly positive at 1% level, suggesting that firms with more cash holdings issue more equity after an increase in CVC average abnormal return. These results do not support the hypothesis that the increase in liquidity is initiated by public firms, and support the conjecture that the increase liquidity is initiated by the capital market. Specifically, the capital market is more willing to provide capital to public firms after learning the growth opportunities from CVC investment behavior.

6. Do Venture Capitalists Mimic?

In previous sections, I find that public firms mimic CVCs' investment behavior. Another question then arises: Do CVCs mimic each other or public firms? This question is particularly intriguing since the investment decision relevance may be driven by a leader-follower model in which public firms are sensitive to CVC investment but not vice versa.

To answer this question, I first examine whether CVCs mimic each other, by using the average abnormal return of all other CVC parent firms as key independent variables, while CVC parent firm's own investment in startups as independent variable. For each CVC parent firm *i* in industry *m* investing in startup *j* (in industry *m* or not), other CVC parent firm averages are measured by the weighted-averages of other CVC parent firms, who do not invest in startup *j*. I use funding ratio, which is measure by the average of funding dummy of CVC parent firm *i*'s portfolio startups, to proxy CVC *i*'s investment in startups, within a CVC parent firm-year combination.

Table 9 column (1) reports the results of using funding ratio as dependent variable, including other CVC parent firm average and firm-specific abnormal return and control variables. Year fixed effect is also included. The coefficient of other CVC parent firm average abnormal return is not statistically significant, suggesting that CVC parent firms do not mimic each other.

To further examine whether CVCs mimic each other. I redefine other CVC parent firm averages by the weighted-averages of other CVC parent firms, who invest in startups in industry *m* but not in startup *j*. Results are reported in column (2), respectively. The coefficient estimate of CVC average abnormal return are not statistically significant in either column, rejecting the hypothesis that CVCs follow each other.

I then examine whether CVCs mimic public firms by using industry average abnormal return are key independent variable, measured by the average of all public firms in industry *m*, excluding CVC parent firm *i*, within an industry-year combination. Corresponding industry average control variables are also included in the regressions. Results, reported in column (3), show that the coefficient estimate on industry average abnormal return is not statistically significant. These results cannot reject the null hypothesis that CVCs' investment decision are not influenced by public firms.

In summary, while I find the influence of CVC investment behavior on public firm investment decision in previous sections, I do not find any evidence of the mimicking behavior of CVCs, i.e. CVCs do not follow each other or public firms. The investment relevance is likely driven by a leader-follower model in which public firms are sensitive to CVC investment but not vice versa.

7. Conclusion

This study has shown that VCs influence public firms’ R&D investment through their investment in startups. I find that a one-standard-deviation increase in VC-backed startup funding amount is associated to 2.2% increase in public firm R&D investment in the following year.

Relying on exogenous variation in CVC parent firm abnormal return, I show that this relation is likely causal. Robustness check results eliminate other plausible explanations, including peer effect between CVC parent firms and public firms and unobservable common factors.

The cross-sectional evidence suggestively points to rational herding, informational learning, technology spillover and product market competition as potential motivations of this mimicking behavior. The influence of CVCs is more pronounced for firms with smaller size, smaller marker share, lower profitability, more growth uncertainty, more innovation and more cash holding, firms having more incentives and higher ability to mimic CVCs.

Furthermore, this investment relevance is likely driven by a leader-follower model in which public firms are sensitive to CVC investment but not vice versa. No evidence supports the peer effect among CVCs either.

By documenting the impact of VC investment on public firm R&D investment decision, this paper sheds light on the future work on better understanding the influence of the private market on the public market.

Appendix A: Variable Definition

The accounting data of public firms between 1980 to 2015 comes from the Compustat database. Financial firms (SIC codes between 2000 and 2999), utilities firms (SIC codes between 4900 and 4999) and government entities (SIC greater than or equal to 9000) are excluded. To ensure consistency throughout the analysis, I exclude observations with missing data for the following variables: R&D investment, cash holdings, firm size, Tobin's *Q*, profitability, tangibility, book leverage, debt issuance and equity issuance. At least three years of nonmissing data is required. Industry groups are defined by three-digit SIC code. At least one CVC-backed startup in the industry group is required.

Financial variable definition is presented below. Time periods are denoted by (*t*) or (*t*-1). If the variables are at the same period, time periods are not specified. Xpressfeed pneumonic variable names in Compustat are denoted in bold.

R&D investment = Research and development expense (*t*) / Total assets (*t*-1) = **xrd** (*t*) / **at** (*t*-1).

Firm size = Log(Sales) = Log(**Sale**).

Cash holdings = Cash and short-term investment / Total assets = **che** / **at**.

Tobin's *Q* = Market value / Book value = (Price close × Common shares outstanding + Total long-term debt + Debt in current liabilities + Total preferred/preference stock (Capital) - Deferred taxes and investment tax credit) / Total assets = (**prcc_f** × **csho** + **dltt** + **dlc** + **pstk** - **txditc**) / **at**.

Profitability = Operating income before depreciation / Total assets = **oibdp** / **at**.

Tangibility = Total net property, plant and equipment / Total Assets = **ppent** / **at**.

Debt issuance = (Total long-term debt (t) + Debt in current liabilities (*t*)) - (Total long-term debt (*t*-1) + Debt in current liabilities (*t*-1))) / Total assets (*t*-1) = ((**dltt**(*t*)+ **dlc**(*t*)) - (**dltt**(*t*-1) + **dlc**(*t*-1))) / **at**(*t*-1).

Equity issuance = (Sale of common and preferred stock (*t*) - Purchase of common and preferred stock (*t*)) / Total assets (*t*-1) = (**sstk**(*t*) - **prstkc**(*t*)) / **at**(*t*-1).

Growth uncertainty is calculated by the standard deviation of annual returns in the current year and the previous two years, within an industry-year combination.

Market share is measured by firm's sales divided by total sales from all firms in the same industry in that year.

Innovation is measured by average R&D investment in the current year and the previous two years, within an industry-year combination.

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Table 1: Summary Statistics

This table reports descriptive summary statistics of main variables used in the study. The sample contains all nonfinancial, nonutility, and nongovernment entity firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. Panel A reports the startup characteristics. Panel B reports sample public firms' characteristics and financial variables (definition see Appendix A). Panel C reports the industry averages and CVC parent firm averages. For each firm *i* in industry *m*, industry averages are the averages of all firms, excluding firm *i*, within an industry-year combination, and CVC averages are the weighted-averages of all CVC parent firms, who invest in startups in industry *m*, within an industry-year combination. Industry groups are defined by three-digit SIC code. At least one CVC-backed startup in the industry group is required. Panel D reports stock return and abnormal return by estimating equation (2), as well as industry average abnormal return and CVC parent firm average abnormal return. All variables are winsorized at the 1st and 99th percentiles.

Panel A: Startup Characteristics

	N	Mean	Median	Std. Dev.
VC-Backed Firms				
Number of VCs	36,305	2.682	1.000	2.863
Number of incubation year	36,305	5.492	4.000	3.032
Total funding amount (million dollar)	28,995	26.715	7.700	102.101
CVC-Backed Firms				
Number of CVCs	5,418	1.712	1.000	1.145
Number of incubation year	5,418	7.203	6.000	4.241
Total funding amount (million dollar)	5,287	61.678	40.000	116.625

Panel B: Public Firm Characteristics and Financial Variables

	N	Mean	Median	Std. Dev.
Firm Characteristics				
Number of public firms	2,484			
Financial Variables				
R&D investment	23,995	0.085	0.042	0.134
Firm Size	23,995	4.518	4.424	2.094
Cash holdings	23,995	0.208	0.127	0.218
Tobin's Q	23,995	1.879	1.240	2.330
Profitability	23,995	0.044	0.106	0.292
Tangibility	23,995	0.230	0.173	0.195
Debt issuance	23,995	0.028	0.000	0.198
Equity issuance	23,995	0.079	0.002	0.392

Panel C: Industry Averages and CVC Parent Firm Averages

	N	Mean	Median	Std. Dev.
Industry Characteristics				
Number of startups	83	21.941	3.000	158.434
Number of public firms	83	29.928	14.000	56.379
Industry Averages				
R&D investment	23,995	0.073	0.073	0.069
Firm Size	23,995	3.776	3.614	1.322
Cash holdings	23,995	0.181	0.153	0.139
Tobin's Q	23,995	1.572	1.427	0.656
Profitability	23,995	0.042	0.081	0.120
Tangibility	23,995	0.191	0.141	0.160
CVC Parent Firm Averages				
R&D investment	23,995	0.059	0.060	0.035
Firm Size	23,995	9.542	9.846	1.426
Cash holdings	23,995	0.129	0.093	0.111
Tobin's Q	23,995	1.640	1.313	0.989
Profitability	23,995	0.143	0.141	0.056
Tangibility	23,995	0.231	0.210	0.119

Panel D: Stock Return and Abnormal Return

	N	Mean	Median	Std. Dev.
Annual stock return	23,995	0.163	0.037	0.686
Annual abnormal return	23,995	-0.100	-0.121	0.678
Industry average abnormal return	23,995	-0.101	-0.077	0.267
CVC parent firm average abnormal return	23,995	-0.069	-0.046	0.276

Table 2: Do Firms Follow Venture Capitalists? Preliminary Results

The sample contains all nonfinancial, nonutility, nongovernment entity, and non-CVC parent firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. This table presents the results of estimating equation (1). In panel A, I use VC-backed startup average funding amount as key independent variable (*INV*). In panel B, I use CVC-backed startup average funding amount as key independent variable. Control variables include firm size, cash holdings, Tobin's *Q*, profitability and tangibility. See Appendix A for variable definition. In the first two columns, dependent variable leads independent variables one year. In the last two columns, dependent variable leads independent variables two years and three years, respectively. All regressions include year fixed effect. Industry groups are defined by three-digit SIC code. All variables are normalized by their sample standard deviation, and winsorized at the 1st and 99th percentiles. Standard errors are clustered at firm level and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: VC-backed Startups

	Public firm R&D investment			
	T+1	T+1	T+2	T+3
	(1)	(2)	(3)	(4)
VC-backed startups average funding amount	0.068***	0.031***	0.042***	0.061***
	(0.013)	(0.009)	(0.010)	(0.011)
Firm-specifics				
Firm size		-0.022	-0.043**	-0.058***
		(0.019)	(0.019)	(0.021)
Cash holdings		0.263***	0.289***	0.293***
		(0.020)	(0.021)	(0.023)
Tobin's *Q*		0.199***	0.098***	0.072***
		(0.025)	(0.020)	(0.022)
Profitability		-0.395***	-0.368***	-0.330***
		(0.029)	(0.025)	(0.029)
Tangibility		-0.045***	-0.054***	-0.064***
		(0.012)	(0.012)	(0.012)
Constant	-0.032	0.305***	0.031	0.056
	(0.094)	(0.077)	(0.067)	(0.071)
Year FE	Yes	Yes	Yes	Yes
Observations	18,846	18,846	17,585	15,743
Adjusted R2	0.013	0.421	0.356	0.329

Panel B: CVC-backed Startups

	Public firm R&D investment			
	T+1	T+1	T+2	T+3
	(1)	(2)	(3)	(4)
CVC-backed startups average	0.068***	0.031***	0.042***	0.061***
funding amount	(0.013)	(0.009)	(0.010)	(0.011)
Firm-specifics				
Firm size		-0.022	-0.043**	-0.058***
		(0.019)	(0.019)	(0.021)
Cash holdings		0.263***	0.289***	0.293***
		(0.020)	(0.021)	(0.023)
Tobin's *Q*		0.199***	0.098***	0.072***
		(0.025)	(0.020)	(0.022)
Profitability		-0.395***	-0.368***	-0.330***
		(0.029)	(0.025)	(0.029)
Tangibility		-0.045***	-0.054***	-0.064***
		(0.012)	(0.012)	(0.012)
Constant	-0.032	0.305***	0.031	0.056
	(0.094)	(0.077)	(0.067)	(0.071)
Year FE	Yes	Yes	Yes	Yes
Observations	18,846	18,846	17,585	15,743
Adjusted R2	0.013	0.421	0.356	0.329

Table 3: Do Firms Follow Venture Capitalists? The Reduced Form

The sample contains all nonfinancial, nonutility, nongovernment entity, and non-CVC parent firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. This table presents the results of estimating equation (1) with CVC parent firm average abnormal return as key independent variable. For each firm *i* in industry *m*, CVC parent firm averages are the weighted-averages of all CVC parent firms, who invest in startups in industry *m*, within an industry-year combination. Control variables include firm size, cash holdings, Tobin's *Q*, profitability and tangibility. See Appendix A for variable definition. Dependent variables lead independent variables one year. Industry groups are defined by three-digit SIC code. At least one CVC-backed startup in the industry group is required. All regressions include year fixed effect. All variables are normalized by their sample standard deviation, and winsorized at the 1st and 99th percentiles. Standard errors are clustered at firm level and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Public firm R&D investment		
	(1)	(2)	(3)
CVC Parent Firm Averages			
Abnormal return	0.070***	0.072***	0.041***
	(0.012)	(0.011)	(0.008)
Firm size		-0.028**	-0.031***
		(0.014)	(0.011)
Cash holdings		-0.032*	-0.024*
		(0.017)	(0.012)
Tobin's *Q*		0.095***	0.011
		(0.018)	(0.012)
Profitability		-0.016	0.018**
		(0.013)	(0.009)
Tangibility		-0.142***	-0.078***
		(0.014)	(0.010)
Firm-specifics			
Abnormal return			0.018***
			(0.006)
Firm size			-0.021
			(0.016)
Cash holdings			0.254***
			(0.018)
Tobin's *Q*			0.201***
			(0.023)
Profitability			-0.393***
			(0.027)
Tangibility			-0.052***
			(0.009)
Constant	0.445***	1.089***	0.922***
	(0.028)	(0.129)	(0.093)
Year FE	Yes	Yes	Yes
Observations	23,995	23,995	23,995
Adjusted R2	0.012	0.025	0.429

Table 4: Robustness Checks with Peer Effect

The sample contains all nonfinancial, nonutility, nongovernment entity, and non-CVC parent firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. This table presents the results of estimating equation (1) with CVC parent firm average abnormal return as key independent variable. For each firm i in industry m, industry averages are measured by the averages of all firms, excluding firm i, within an industry-year combination. In column (1), CVC parent firm averages are measured by the weighted-averages of all CVC parent firms, who invest in startups in industry m, within an industry-year combination. In column (2), CVC averages are measured by the weighted-averages of all CVC parent firms, who themselves are not in but invest in startups in industry m. In column (3), CVC averages are measured by the weighted-averages of all CVC parent firms, whose industries do not have business relationship with but invest in industry m. In column (4), CVC averages are measured by the weighted-averages of all CVC parent firms, who invest the first round of financing in industry m. Control variables include firm size, cash holdings, Tobin's Q profitability and tangibility. See Appendix A for variable definition. Dependent variables lead independent variables one year. Industry groups are defined by three-digit SIC code. All regressions include year fixed effect. All variables are normalized by their sample standard deviation, and winsorized at the 1st and 99th percentiles. Standard errors are clustered at firm level and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Public firm R&D investment			
	(1)	(2)	(3)	(4)
CVC parent firm average abnormal return	0.029***	0.032***	0.059**	0.035**
	(0.008)	(0.008)	(0.028)	(0.015)
Firm-specific abnormal return	0.023***	0.022***	0.008	0.020**
	(0.006)	(0.006)	(0.010)	(0.009)
Industry Averages				
Equity shock	0.002	0.005	0.019**	0.181
	(0.005)	(0.005)	(0.008)	(0.190)
Firm size	-0.042***	-0.044***	-0.043	-0.005
	(0.014)	(0.014)	(0.028)	(0.006)
Cash holdings	0.302***	0.300***	0.278***	0.020**
	(0.024)	(0.024)	(0.037)	(0.009)
Tobin's *Q*	-0.057***	-0.060***	-0.105***	-0.225**
	(0.014)	(0.014)	(0.019)	(0.111)
Profitability	0.050**	0.046*	-0.008	0.039
	(0.025)	(0.025)	(0.035)	(0.056)
Tangibility	-0.036***	-0.035***	0.049**	0.039
	(0.012)	(0.012)	(0.025)	(0.074)
CVC parent firm average controls	Yes	Yes	Yes	Yes
Firm-specific controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	23,995	23,995	7,257	11,720
Adjusted R2	0.470	0.470	0.447	0.454

Table 5: Robustness Checks with Omitted Variables

The sample contains all nonfinancial, nonutility, nongovernment entity, and non-CVC parent firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. This table presents the results of estimating equation (1) with CVC parent firm average abnormal return as key independent variable. For each firm *i* in industry *m*, CVC averages are measured by the weighted-averages of all CVC parent firms, who themselves are not in but invest in startups in industry *m*. At least one CVC-backed startup in the industry group is required. Industry averages are measured by the averages of all firms, excluding firm *i*. Industry groups are defined by three-digit SIC code. Control variables, including firm size, cash holdings, Tobin's *Q*, profitability and tangibility. See Appendix A for variable definition. Dependent variables lead independent variables one year. All regressions include year fixed effect. Dependent variable lead independent variables one year. Column (1) replaces the firm-specific abnormal return with stock return and lead-one-year stock return. In column (2), CVC average controls, firm specific abnormal return and controls, and industry abnormal return and controls are at the same period with the dependent variable. In column (3), sample is restricted to 28 industries, startups in which receive 90% of VC investment. All variables are normalized by their sample standard deviation, and winsorized at the 1st and 99th percentiles. Standard errors are clustered at firm level and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Public firm R&D investment		
	(1)	(2)	(3)
CVC parent firm average abnormal return	0.029***	0.004***	0.047***
	(0.008)	(0.001)	(0.012)
Firm-specifics			
Stock return (+1)	0.065***		
	(0.007)		
Stock return	0.043***		
	(0.007)		
CVC parent firm average controls	Yes	Yes	Yes
Firm-specific abnormal return	No	Yes	Yes
Firm-specific controls	Yes	Yes	Yes
Industry average abnormal return and controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	23,995	23,711	18,655
Adjusted R2	0.475	0.417	0.446

Table 6: Do Firms Follow Venture Capitalists? 2SLS Results

The sample contains all nonfinancial, nonutility, nongovernment entity, and non-CVC parent firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. This table presents the results of estimating equation (1) with CVC parent firm average abnormal return as the instrument variable for CVC-backed startup average funding amount and CVC parent firm average R&D investment. For each firm *i* in industry *m*, CVC averages are measured by the weighted-averages of all CVC parent firms, who themselves are not in but invest in startups in industry *m*. At least one CVC-backed startup in the industry group is required. Industry averages are measured by the averages of all firms, excluding firm *i*. Industry groups are defined by three-digit SIC code. Panel A reports first-stage regression results. F-statistic, Cragg-Donald Wald F-statistic and SW Chi-sq-statistic are presented. Panel B reports second-stage regression results. Panel C reports first-stage regression results adding lagged-one-year and lagged-two-year CVC parent firm average abnormal return as instrument variables in each column, respectively. Control variables include firm size, cash holdings, Tobin's *Q*, profitability and tangibility. See Appendix A for variable definition. Dependent variable leads one year. All regressions include year fixed effect. All variables are normalized by their sample standard deviation, and winsorized at the 1st and 99th percentiles. Standard errors are clustered at firm level and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: First-Stage Regression

	CVC-backed startup avg. funding amount (1)	CVC parent firm avg. R&D investment (2)
CVC Parent Firm Averages		
Abnormal return	0.026***	0.086***
	(0.007)	(0.005)
Firm size	0.195***	-0.205***
	(0.007)	(0.010)
Cash holdings	-0.014	0.482***
	(0.011)	(0.013)
Tobin's *Q*	0.019*	0.075***
	(0.012)	(0.015)
Profitability	0.008	0.249***
	(0.009)	(0.010)
Tangibility	0.050***	-0.028**
	(0.012)	(0.012)
Firm-specific abnormal return and controls	Yes	Yes
Industry average abnormal return and controls	Yes	Yes
Year FE	Yes	Yes
Observations	18,846	23,203
Adjusted R2	0.621	0.720
F-statistic	13.67***	254.69***
Cragg-Donald Wald F-statistic	15.16***	360.71***
SW Chi-sq-statistic	13.67***	254.69***

Panel B: Second-Stage Regression

	Public firm R&D investment	
	(1)	(2)
CVC-backed startup avg. funding amount	1.352**	
	(0.571)	
CVC parent firm avg. R&D investment		0.289***
		(0.091)
CVC Parent Firm Averages		
Firm size	-0.308***	0.032*
	(0.116)	(0.018)
Cash holdings	-0.010	-0.168***
	(0.022)	(0.044)
Tobin's *Q*	-0.042*	-0.042***
	(0.024)	(0.014)
Profitability	0.008	-0.059***
	(0.017)	(0.023)
Tangibility	-0.128***	-0.028***
	(0.034)	(0.011)
Firm-specific abnormal return and controls	Yes	Yes
Industry average abnormal return and controls	Yes	Yes
Year FE	Yes	Yes
Observations	18,846	23,203
Adjusted R2	-0.096	0.467

Panel C: First-Stage Multiple-Period Effect

	CVC-backed startup avg. funding amount	
	(1)	(2)
CVC Parent Firm Averages		
Abnormal return	0.024***	0.045***
	(0.007)	(0.008)
Abnormal return (-1)	0.040***	0.067***
	(0.007)	(0.007)
Abnormal return (-2)		0.071***
		(0.006)
CVC parent firm average controls	Yes	Yes
Firm-specific abnormal return and controls	Yes	Yes
Industry average abnormal return and controls	Yes	Yes
Year FE	Yes	Yes
Observations	18,846	23,203
Adjusted R2	0.621	0.720
F-statistic	21.60***	71.97***
Cragg-Donald Wald F-statistic	25.49***	73.34***
SW Chi-sq-statistic	43.53***	217.64***

Table 7: Cross-Sectional Heterogeneity

The sample contains all nonfinancial, nonutility, nongovernment entity, and non-CVC parent firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. This table presents the results of estimating equation (1) with interaction terms between CVC parent firm average abnormal return and firm characteristics variables, including firm size, market share, profitability, growth uncertainty, innovation and cash holdings, as key variables in each column, respectively. For each firm *i* in industry *m*, CVC averages are measured by the weighted-averages of all CVC parent firms, who themselves are not in but invest in startups in industry *m*. At least one CVC-backed startup in the industry group is required. Industry averages are measured by the averages of all firms, excluding firm *i*. Industry groups are defined by three-digit SIC code. Control variables, including firm size, cash holdings, Tobin's *Q*, profitability and tangibility. See Appendix A for variable definition. Dependent variables lead independent variables one year. All regressions include year fixed effect. Market share, growth uncertainty and innovation is included in column (2), (4) and (5), respectively. All variables are normalized by their sample standard deviation, and winsorized at the 1st and 99th percentiles. Standard errors are clustered at firm level and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Interactions with CVC average abnormal return						
Firm size	-0.026***					
	(0.008)					
Market share		-0.012***				
		(0.003)				
Profitability			-0.051***			
			(0.017)			
Growth uncertainty				0.041***		
				(0.014)		
Innovation					0.030**	
					(0.012)	
Cash holdings						0.021**
						(0.009)
CVC parent firm average abnormal return and controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm-specific abnormal return and controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry average abnormal return and controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,995	23,995	23,995	21,260	23,995	23,995
Adjusted R2	0.470	0.470	0.472	0.477	0.743	0.470

Table 8: Other Plausible Mechanisms

The sample contains all nonfinancial, nonutility, nongovernment entity, and non-CVC parent firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. Panel A presents the results of estimating equation (1) with R&D sudden beginning dummy and R&D sharp increase dummy as dependent variable in each column, respectively. For each firm *i* in industry *m*, CVC averages are measured by the weighted-averages of all CVC parent firms, who themselves are not in but invest in startups in industry *m*. At least one CVC-backed startup in the industry group is required. Industry averages are measured by the averages of all firms, excluding firm *i*. Industry groups are defined by three-digit SIC code. Control variables, including firm size, cash holdings, Tobin's *Q*, profitability and tangibility. See Appendix A for variable definition. Dependent variables lead independent variables one year. All regressions include year fixed effect. All variables are normalized by their sample standard deviation, and winsorized at the 1st and 99th percentiles. Standard errors are clustered at firm level and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Irrational Herding

	Public firm R&D	
	Sudden beginning	Sharp increase
	(1)	(2)
CVC parent firm average abnormal return	0.001	-0.003
	(0.002)	(0.003)
CVC parent firm average controls	Yes	Yes
Industry average abnormal return and controls	Yes	Yes
Firm-specific abnormal return and controls	Yes	Yes
Year FE	Yes	Yes
Observations	23,995	23,995
Adjusted R2	0.116	0.228

Panel B1: Liquidity from Capital Market

	Public firm	
	Debt Issuance	Equity Issuance
	(1)	(2)
CVC parent firm average abnormal return	0.003	0.054***
	(0.010)	(0.013)
CVC parent firm average controls	Yes	Yes
Industry average abnormal return and controls	Yes	Yes
Firm-specific abnormal return and controls	Yes	Yes
Year FE	Yes	Yes
Observations	23,995	23,995
Adjusted R2	0.020	0.309

Panel B2: Liquidity from Capital Market and Cash Holdings

	Public firm	
	Debt Issuance	Equity Issuance
	(1)	(2)
Cash holdings × CVC parent firm average abnormal return	-0.003	0.051***
	(0.008)	(0.012)
CVC parent firm average abnormal return and controls	Yes	Yes
Industry average abnormal return and controls	Yes	Yes
Firm-specific abnormal return and controls	Yes	Yes
Year FE	Yes	Yes
Observations	23,995	23,995
Adjusted R2	0.020	0.312

Table 9: Do Venture Capitalists Mimic?

The sample contains all nonfinancial, nonutility, nongovernment entity, and CVC parent firms from Compustat database between 1980 and 2015 with nonmissing data for all variables. This table presents the results of estimating equation (1) with other CVC parent firm average and industry average abnormal return as key independent variables. In column (1), for each CVC parent firm *i* in industry *m* investing in startup *j*, other CVC parent firm averages are measured by the weighted-averages of all other CVC parent firms, who do not invest in startup *j*. In column (2), other CVC parent firm averages are measured the weighted-averages of other CVC parent firms, who invest in startups in industry *m* but not in startup *j*. In column (3), industry averages are measured by the averages of all firms, excluding firm *i*. Industry groups are defined by three-digit SIC code. At least one CVC-backed startup in the industry group is required. Control variables, including firm size, cash holdings, Tobin's *Q*, profitability and tangibility. See Appendix A for variable definition. Dependent variables lead independent variables one year. All regressions include year fixed effect. All variables are normalized by their sample standard deviation, and are winsorized at the 1st and 99th percentiles. Standard error are clustered at firm level and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	CVC parent firm investment in startups		
	(1)	(2)	(3)
Other CVC parent firm average abnormal return	-0.566	-0.020	
	(0.643)	(0.051)	
Industry average abnormal return			-0.041
			(0.030)
Other CVC parent firm average controls	Yes	Yes	No
Industry average controls	No	No	Yes
Firm-specific abnormal return and controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	1,017	1,005	1,017
Adjusted R2	0.393	0.353	0.430