The emerging public investments in private companies

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Abstract

Start-up companies have primarily been financed by venture capitalists but have started to receive increased investments from public investors such as hedge funds, mutual funds and pension funds. In this thesis, we find that companies that receive both venture capital and public investments have a higher probability to undergo an initial public offering or exit through M&A. We find significant differences in the likelihood of exit through IPO, but not when exiting through M&A. To the best of our knowledge, our study is one of the first studies to examine the impact from public investments in private companies and the effect such investments have on the probability of exit. Earlier studies have either focused on traditional risk capitalist, such as VCs and CVCs or the effect public investments have on public companies. Our findings shed light on the increasing investment activities from public investors in private biotech companies and how these investments affect the exit events. Our findings also suggest that VC-backed IPOs have a higher pre-money valuation than both VC and public backed-IPOs.

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1. Introduction

Private companies have experienced a dramatic change in their financing in recent years. Start-ups have primarily been financed by venture capitalists but have started to receive increasing investments from public market investors, such as hedge funds, mutual funds and pension funds[1] (Huang, Mao, Wang and Zhou, 2017). There is also a new phenomenon, that venture capitalists tend to keep their positions for a long time, even after the firm goes public. Traditionally, venture capitalists have invested in emerging companies with an approximate time horizon of five years, normally exiting through an initial public offering or a merger and acquisition. Mutual funds are generally underrepresented on board seats compared to venture capitalists, since they usually have weaker cash flow rights and are less involved in the corporate governance. Hedge funds tend to invest in later rounds when companies are close to go public or get acquired, hoping to boost their portfolio performances (Lerner, Chernenko and Zeng, 2017).

This thesis aims at investigating how public investors' participation in start-up firms in the U.S. market affects the probability of a successful exit and whether it differs from venture capital fund participation. An exit is successful if a private company either goes public or gets acquired (Huang et al. 2017). This study is motivated by the increasing trend of participation from traditional public market investors concerning the financing of private companies. The increasing trend is highlighted in figures 1.1 and 1.2 below. The two graphs display public firms' increased investment activities in private US biotech companies. From year 1998 to 2018, the number of financing rounds and the accumulated amount invested have increased substantially.

Figure 1.1: Number of financing rounds

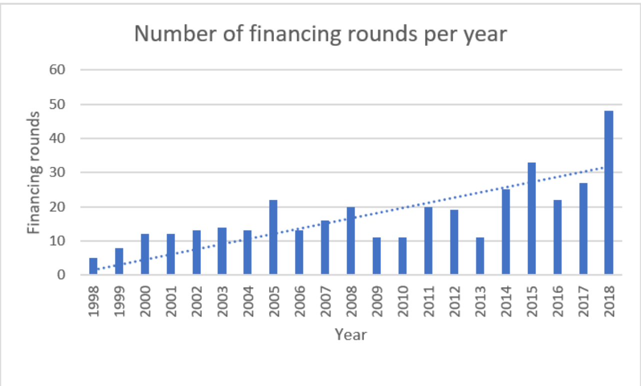
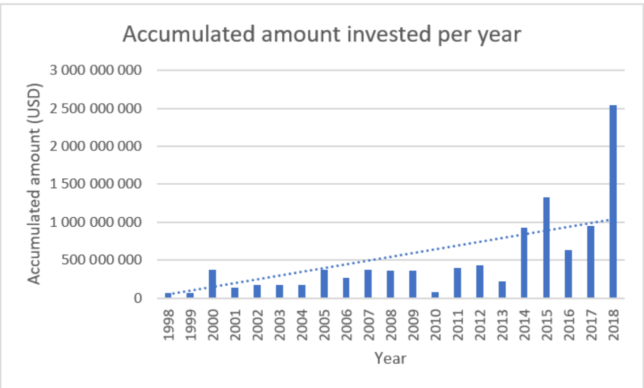


Figure 1.2: Accumulated amount invested



[1] We will thereafter refer to hedge funds, mutual funds and pension funds as public investors

Prior literature on the financing of private companies have primarily focused on traditional venture capitalists and to a lesser degree on other investors, such as public investors. This study sheds new light on the importance of public investors' investments by examining a sample of 2,227 companies backed by either venture capitalists and public investors or solely venture capitalists. Dai (2007) studies the performance of firms by comparing VC-invested PIPEs to HF-invested PIPEs. Dai (2007) concludes that investor identity matters as he finds that the stock performance is significantly better for VC-invested firms.[2] To further illustrate the increased importance of public investors, figure 1.3 and 1.4 below graphically display their increased investment activities as a percentage of total investments. From year 1998 to 2018, the financing rounds and the accumulated amount invested by public investors have increased in comparison to all type of investors. The findings in this thesis supports the importance of public investors' participation in start-up companies. Private companies financed by both venture capitalists and public investors experience a higher probability of a successful exit than companies solely backed by venture capitalists.

Figure 1.3: Public-backed financing rounds as a percentage of total financing rounds

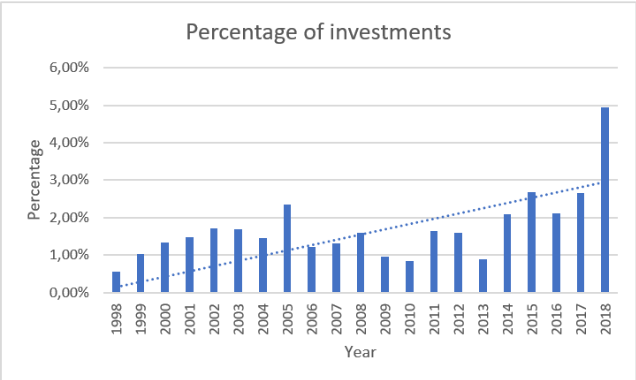
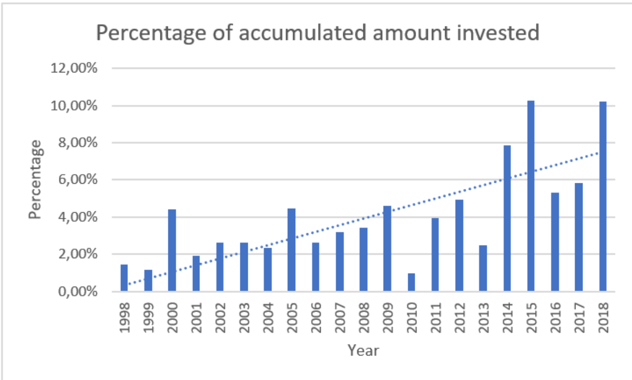


Figure 1.4: Accumulated amount invested by public investors in percentage



Furthermore, this study explores the difference in the pricing of IPOs, by comparing companies that received both VC and public investments to companies that have solely received VC investments. The study is related to other works that explore the determinants of the IPO valuation. Loughran and McDonald (2013) studies the role of S-1[3] in the pricing of IPOs and find that higher absolute offer price revisions and first-day returns are associated with ex ante uncertainty about an IPO's pricing.

[2] A PIPE is a private investment in public equity.
[3] Form S-1 is the first Securities and Exchange Commission filing in the IPO process.

2. Literature review

Public market players play an important role in the IPO process of private companies. According to Huang et al. (2017), the increased participation from public investors results in a reduced underpricing and serves as a substitute to all-star analysts. It is explained by the fact that institutions can provide secondary market support, substituting the role of all-star analysts attracting investors in the post-IPO market. IPO seems to come in cluster, where an increased rate of IPOs for a specific sector positively affects the number of IPOs in the following years (Chemmanur, et al., 2010). Furthermore, less information asymmetry and information intensity increase the likeliness of a successful exit. On the other hand, Danzon, Epstein and Nicholson (2007) argue that M&A-activity is primarily due to either the acquired or the acquiring firm being in trouble or potentially both.[4]

Ozmel, Robinson and Stuart (2013) argue that large capital injections and strategic capital are of utmost importance in the biotechnology sector. They conclude that VC funding as well as funding through alliances increase the likeliness of going public or being acquired. Alliances gain public confidence when one of the firms is young and small, with questionable quality and the other firm is a large, well-recognized firm. The more mature firm helps the young company to attract risk averse investors. Findings from Stuart, Hoang and Hybels (1999) indicate that companies involved in salient strategic alliances, experience IPOs more frequently and higher valuations. Cooperating activities (alliances) as well as the likelihood of an IPO increase when private companies are backed by VCs (Hsu, 2006).

Barry, Muscarella, Peavy III and Vetsuypens (1990) argue that VCs take an active role in the private companies they are investing in. This is reflected by high ownership, board seat request and long-term investment, where the position is maintained beyond the IPO. Having several board seats and powerful control rights make venture capitalists more experienced at timing the IPO of private companies when the market conditions are favorable. This is mostly evident in the biotechnology industry, as financing is provided in stages and venture capitalists have the flexibility to time IPO when equity values are high (Lerner, 1994; Ball, Chiu and Smith, 2011). VCs are considered to play an important role in developing and shaping nascent companies. Hochberg, Ljungqvist and Lu (2007) study the effect of VCs

[4] For large firms, problems usually appear from over-capacity regarding patent expirations and/or limitations in the product pipeline. Small firms primarily suffer from low growth expectations, costly R&D, low cash-ratio, high burn rate and few market products (Danzon, Epstein and Nicholson, 2007).

syndicates. They find that more networked VCs perform better, which is displayed by the increased rate of successful exits. As innovating firms are favored by venture capitalists, VCs also contribute to shortening the time it takes to bring a product to the market (Hellmann and Puri, 2000, 2002).

Megginson and Weiss (1991) find that VCs function as a certifier of quality, leading to lower initial returns for the investors. The certification effect steams from the financial and reputational capital VCs bring to the private firm. In addition, the presence of VCs lowers the cost of going public, thereby increasing the proceeds of the issuing firm. They further present evidence of VCs investing for the long-run, consistent with Barry et al. (1990). Finally, VCs lower the information asymmetry by their ability to recruit high quality underwriters and auditors, which will lower the uncertainty and make it possible to attract large financial institutions. Therefore, the cost of going public is greatly reduced (Megginson & Weiss, 1991). Hsu (2004) also concludes that well reputed VCs add value to the firm through the certification effect. He states that companies are willing to give a higher discount rate to well established VCs. Underwriters' reputation is also an important factor when the IPO price is determined. An underwriter with a high reputation lowers the initial returns following an IPO. The difference in the returns is due to the reduction of information asymmetry (Carter and Manaster, 1990).

2.1 Hypotheses development

In this section, we hypothesize whether public investors' participation in startups increases the probability of a successful exit and whether the effect is different from venture capital participation. Dai (2007) finds that venture capitalists tend to keep their stake longer after they have invested in a PIPE transaction, whereas hedge funds cash out their positions shortly after. Furthermore, VC-backed companies gain significant ownership, request board seats and have a substantially better stock performance both in the short and the long run. Therefore, we believe that the same pattern will arise in the private market.

- H1: Ceteris Paribus, a startup company financed by both VC and public investors experiences a higher probability of exit (IPO or M&A) than a start-up company financed by venture capitalists.

Given that the first hypothesis is supported, our second hypothesis is built on the companies that have conducted an IPO. There are several determinants for the valuation of an IPO. We hypothesize whether there is any difference between the pricing of an IPO between companies that received both VC and public investments to companies that have solely received VC investments. Brophy, Ouimet and Sialm (2006) argue that hedge funds act as investors of last resort in PIPE transactions. Hedge funds usually invest in young risky companies with severe information asymmetry. To compensate for this, they require substantial discounts, negotiate repricing rights and they also short the underlying security to protect themselves. The findings in Brophy, Ouimet and Sialm (2006) imply that companies that have received financing from hedge funds underperform those that have received financing from other investors.

The difference in the valuation of IPOs could also be a consequence of the certification hypothesis. Due to severe information asymmetry between insiders of the issuing firm and outside investors, third party certification of the value of securities plays an important role. Megginson and Weiss (1991) support the certification hypothesis by finding that VC-backed companies experience a lower underpricing. Venture capital participation in companies serve as a signal of quality which in turn attracts better underwriters and leads to more analyst coverage. Furthermore, the reputation of VCs as value-adding investors signals the market that the company is undervalued. Dai (2007) concludes that ownership change and how long investors keep their stake after PIPE transactions have a positive effect on the stock performance of the company. This seems to be driven by the certification effect of VCs' active and long-term commitments.

- H2: Ceteris Paribus, a VC-backed IPO has a higher pre-money valuation than a VC- and public-backed IPO.

3. Method

Our objective is to empirically connect the outcome of interest (exit through IPO or M&A) with different sources of risk capital. We follow the method used by Ozmel, Robinson and Stuart (2013), the Cox proportional hazard model. We are interested in whether the company goes public or gets acquired. We want to investigate the likelihood of each event happening as a function of time, controlling for firm, investor and market characteristics. We will test the proportional hazard assumption by including time varying variables for all our covariates to decide upon what interaction terms to be included in the final regression. This test will be conducted for all different specifications. The first test of the proportional hazard assumption is reported in the results and analysis section while the remaining tests related to the alternative specifications are tabulated in the appendix.

We find the Cox proportional hazard model as best suited to study our main hypothesis, since it is a survival model that measures the probability of an event occurring at a specific point in time (Cox, 1972). It also measures the difference in survival between two groups and studies how different covariates affect the outcome. It is very important to control for firm quality due to unobserved, time-invariant, firm-level heterogeneity[5]. It is also critical to update information about the covariates on a frequent basis to keep within-firm variation constant over time. Since we are interested in the probability of an event occurring as a function of time, we need to specify time in a way such that it satisfies the econometric assumptions of the proportional hazard model but also secure a sensible economic interpretation. For this reason, we update our covariates on a monthly basis (Ozmel, Robinson and Stuart, 2013).

3.1 Independence assumption and censoring

In order to use the Cox proportional hazard model, we need the competing risks to be independent of each other. If the independence assumption does not hold, there is no direct method available to analyze competing risks simultaneously. A major problem regarding the independence assumption is that it cannot be tested whether the assumption holds or not. However, there exist several methods to investigate and potentially reduce the severity of the bias arising from failure of the independence assumption. We are going to include several

[5] Unobserved heterogeneity arises when independent variables are correlated with variables not included in the regressions. Funding rounds could be correlated with firm quality. To reduce the risk of unobserved heterogeneity, we include control variables such as patents, strategic alliances and location to control for firm quality.

covariates that could potentially affect the outcomes from our model. Furthermore, we make use of time-varying parameters for those covariates failing the test of the proportional hazard assumption.

Censoring is when observations in a study do not experience the event of interest. In our study, we are interested in whether a company goes public or gets acquired. There will be some companies that will not experience either of these two events under the duration of the study. These observations are censored. In such a scenario, using ordinary least squares regression would be inappropriate, since it cannot effectively handle the censoring of observations. Furthermore, censoring must be *non-informative* (random), to prevent bias. Censoring must be independent of the companies' covariates and of how far they have made it in the study. This means that the observations being censored should not be more likely to fail (be affected by an event) than the observations not being censored (Cox, 1972).

3.2 The cox proportional hazard model

The cumulative distribution function is specified as $F_i(t) = \Pr(T \leq t)$ and the survivorship function (3.1) is given by:

$$S_i(t) = 1 - F_i(t) = \Pr(T > t), \quad (3.1)$$

where T is the time of the event. In the beginning of the survival stage (t=0), the probability that the event has not occurred is 1 (100% probability of survival) and as t → ∞, the probability is 0 (0% probability of survival). The current time is represented by t and the final time of the survival period is T.

We are interested in the probability of an event being realized during a short time interval $(t \rightarrow t + dt)$ for firm *i* at time *t*. This is expressed in the hazard function (3.2):

$$h_i(t) = \Delta t \overset{lim}{\longrightarrow} 0 \; \frac{\Pr(t \leq T < t + dt \; | T \geq t)}{\Delta t} = \frac{f_i(t)}{S_i(t)} \quad (3.2)$$

The cumulative hazard function (3.3) accounts for the accumulated risk up until a certain point in time.

$$h_i(t) = -\ln S_i(t) \quad (3.3)$$

The hazard function is thus given by equation (3.4), consisting of the underlying baseline hazard function h(0), the vector of covariates x and the coefficient vector β.

$$h_i(t|\omega_i) = \omega_i h(0)e^{x'\beta}$$ [6] (3.4)

The hazard ratio (3.5) is useful when the relative risk (hazard ratio) is assumed to be constant over time. If the ratio does not stay constant over time, we cannot use the Cox proportional hazard model. This essentially means that the impact of covariates should stay the same over time. A hazard ratio below 1 indicates a positive relationship on survival between the covariate and the dependent variable. A value above 1 indicates a negative effect on survival. The hazard ratio intends to show the relationship between two groups or individuals. [7]

$$\widehat{HR} = \frac{\hat{h}\,(t,x_i)}{\hat{h}\,(t,x_j)} = = \frac{\hat{h}_0(t)^{x_i\beta x}}{\hat{h}_0(t)^{x_j\beta x}} = \frac{e^{x_i\beta x}}{e^{x_j\beta x}} \qquad (3.5)$$

3.3 The propensity score matching

To control for the endogeneity of private and public investor-backed companies, we perform the propensity score matching test developed by Dehejia and Wahba (1999, 2002). The procedure aims at addressing the endogeneity concern that may arise from the differences of VC- and public-backed exits. Start-up companies may receive financing from private or public investors based on their firm characteristics and in different stages of their life cycle. For this reason, the financing choice is not random and the differences in financing may be responsible for diversities in the probability of exiting through IPO or M&A (Ivanov and Xie, 2010). By conducting the propensity score matching regression, it is possible to compare treated (i.e. VC and public-backed companies) and untreated companies (VC-backed companies) with similar covariate characteristics. The test is used to rule out that our results from the Cox-regressions are due to differences in the control variables (Dehejia and Wahba, 2002).

Matching firms from the treated group with the untreated group help us deal with the self-selection issue. We decide to use the nearest neighbor matching approach, allowing for replacement (one comparison unit could be matched against treatment units more than once). We further use a single comparison unit (comparison of one treatment unit against one untreated unit). The single nearest neighbor approach with replacements is suitable when the reduction in bias is of most importance, and the precision of the estimates are acceptable

[6] The frailty parameter ω_i in equation (3.4), which is a time-invariant parameter capturing unmeasured firm-level heterogeneity cannot be estimated due to the limitation of the Stata license used.

[7] Survival analysis is used widely in many sciences. In medicine, researchers perform studies of the effect of treatment on patients and survival. In finance research, the methodology has only recently gain ground (e.g. (Ozmel *et al.* 2013)).

(Dehejia and Wahba, 2002). The first step in the matching algorithm is to estimate a probit model. The dependent variable is public investor, indicating if a start-up company has received public investments. Secondly, we match each VC and public-backed exit against VC-backed exits with the closest propensity score. A propensity score is the probability that a company will receive public investments conditional on a set of independent variables (Ivanov and Xie, 2010). The results of the propensity score matching test can be found in the robustness section.

4. Data

4.1 Sample

A sample of 2,278 companies backed by either private and/or public investors were retrieved from Thomson Financial's VentureXpert database. The sample consists of private biotechnology companies domiciled in the U.S., founded during the time period 1965 - 2018. Each company is then matched to a private and/or a public investor respectively, indicating if the company is venture-backed, backed by public institutions or if it has received funding from both sources of capital[8]. For the companies that have not experienced any event, we assign the last date of 2018 (Dec 31, 2018) as an indication of the most recent sign of activity. The company founded date and company event date (IPO or M&A) were missing on approximately 200 companies. These were searched for and collected manually from websites such as Crunchbase, Open Corporates, Nasdaq and U.S. Securities and Exchange Commission. We were not able to find information for 49 of the 200 companies and therefore those were excluded, decreasing our sample to 2,229 companies. Since the time of study is measured in months (i.e, time between the company's founded date and event date), having companies with a survival time equal to zero adds no value to our study. Thus, two additional companies were excluded, resulting in a final sample of 2,227 companies.

The sample includes data on the total funding amount invested from private and public investors. The sample also includes the number of funding rounds each company has been involved in. We noted that the total funding amount the companies received ranged from the date of foundation until after the event had occurred. Since we are only interested in how much funding companies received before the event of interest, we corrected for this by only including funding amounts up until this date. In table 4.1 and 4.2 below we present summary statistics, covering successful exits and the average number of patents each year. There are 1957 VC-backed firms in the sample, where 430 firms went public and 448 were acquired. In comparison, there are only 270 companies backed by both VC and public investors in the sample, where 121 of them went public and 49 were acquired.

[8] Since there are only nine companies which have received financing from public investors only, we choose to combine these companies with companies which have received financing from private and public investors.

Table 4.1: Total exits

	Total exits		IPO		M&A	
	Private	***Public***	***Private***	***Public***	***Private***	***Public***
Exits	***878***	***170***	***430***	***121***	***448***	***49***
Total nr. firms	*1957*	*270*	*1957*	*270*	*1957*	*270*
%	**44.86%**	**62.96%**	**21.97%**	**44.81%**	**22.89%**	**18.15%**

Table 4.2: Summary statistics
The table presents the year of company foundation, how many firms were founded that year, number of companies that went public or got acquired and finally the average number of patents during that specific year. The first section in the table presents the total, the second presents only VC financed firms whereas the last presents companies financed by both VC and public investors.

					Private				Public			
Year	*Firms founded*	*IPO*	*M&A*	*Avg. Patents*	*Firms founded*	*IPO*	*M&A*	*Avg. Patents*	*Firms founded*	*IPO*	*M&A*	*Avg. Patents*
<1980	32	9	9	0.0	29	8	8	0.0	3	1	1	0.0
1980	18	3	5	0.0	16	2	5	0.0	2	1	0	0.0
1981	36	9	12	0.0	32	8	10	0.0	4	1	2	0.0
1982	15	4	4	1.0	15	4	4	1.0	0	0	0	0.0
1983	24	6	9	0.0	22	5	9	0.0	2	1	0	0.0
1984	15	4	6	2.0	12	2	5	2.0	3	2	1	0.0
1985	15	4	6	0.0	14	3	6	0.0	1	1	0	0.0
1986	23	7	8	0.0	19	4	7	0.0	4	3	1	0.0
1987	40	14	10	1.0	36	12	9	1.0	4	2	1	0.0
1988	32	7	9	4.0	27	4	8	4.0	5	3	1	0.0
1989	25	8	6	2.0	23	7	6	2.0	2	1	0	0.0
1990	24	10	6	1.0	21	8	6	1.0	3	2	0	0.0
1991	22	3	9	1.0	20	2	8	1.0	2	1	1	0.0
1992	51	14	16	2.0	43	7	15	2.0	8	7	1	0.0
1993	40	12	15	1.5	35	9	15	1.5	5	3	0	0.0
1994	42	14	12	2.5	37	12	11	2.5	5	2	1	0.0
1995	47	19	16	4.3	42	17	13	4.3	5	2	3	0.0
1996	51	16	20	1.7	44	13	18	1.7	7	3	2	0.0
1997	67	19	20	4.3	57	15	17	4.3	10	4	3	0.0
1998	62	16	15	3.3	49	10	11	3.3	13	6	4	0.0
1999	58	21	18	3.4	50	18	14	3.4	8	3	4	0.0
2000	85	31	14	15.4	79	29	14	15.4	6	2	0	0.0
2001	80	25	21	4.0	71	20	20	4.0	9	5	1	0.0
2002	68	21	22	4.1	63	17	22	4.1	5	4	0	0.0
2003	79	24	18	6.3	69	22	15	6.3	10	2	3	0.0
2004	71	16	13	2.6	64	13	12	2.6	7	3	1	0.0
2005	90	26	23	4.8	84	23	22	5.2	6	3	1	1.0
2006	100	26	35	3.1	84	16	32	3.1	16	10	3	0.0
2007	94	31	28	2.8	86	27	25	2.8	8	4	3	0.0
2008	101	33	26	1.9	84	24	21	2.0	17	9	5	1.0
2009	82	20	29	3.2	75	16	26	3.3	7	4	3	2.5
2010	70	11	15	2.3	61	9	13	2.5	9	2	2	1.0
2011	103	26	10	2.3	83	15	10	2.5	20	11	0	1.0
2012	65	9	5	2.6	55	4	5	2.6	10	5	0	2.9
2013	93	15	3	4.8	78	11	2	4.6	15	4	1	5.7
2014	77	8	3	4.5	70	6	3	4.2	7	2	0	6.0
2015	106	6	0	4.3	101	5	0	4.3	5	1	0	4.6
2016	67	3	1	3.7	55	2	1	3.5	12	1	0	4.9
2017	42	0	0	3.2	38	0	0	3.0	4	0	0	4.3
2018	15	1	0	2.0	14	1	0	2.0	1	0	0	2.0
Total/Avg	**2227**	**551**	**497**	**2.8**	**1957**	**430**	**448**	**2.8**	**270**	**121**	**49**	**0.9**

The correlation matrix is displayed in table 4.3. Unsurprisingly, we observe a high correlation between accumulated amounts invested and funding rounds. A similar pattern can be noticed for the variables firm age and funding rounds. Centrality is strongly (positively) correlated with funding rounds, accumulated amounts invested, and in particular firm age. This suggests that centrality becomes more important as the company matures. It is supported by our test of the proportional hazard assumption (reported in section 4 and the appendix). In addition, it seems that funding rounds and accumulated amounts invested are relatively highly correlated with sum of patents last five years. One explanation for this could be that an innovative company files more patent applications. More innovative companies should also be of greater interest for risk capitalists.

Table 4.3: Correlation matrix

Table 4.3 shows the correlation between the independent variables. The numbers in the top row correspond to the labeled covariates in the first column.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Public investor dummy								
2. Sum of patents, last five years	0.002							
3. Sum of alliances, last five years	0.072***	0.001						
4. Location	0.088***	0.028***	-0.001***					
5. Funding rounds	0.086***	0.161***	0.122***	0.05***				
6. Accumulated amount invested	0.14***	0.275***	0.118***	0.145***	0.5***			
7. Firm age	0.024***	0.117***	0.031***	0.04***	0.48***	0.299***		
8. Centrality	0.02***	0.048***	0.016***	0.097***	0.295***	0.163***	0.54***	
9. S&P500 return, 3-months	0,000	0.012***	0.005**	0.001	0.014***	-0.006***	0.013***	0.004**

, **, and * denote statistical significance at the 10, 5 and 1 percent level, respectively.*

4.2 Independent variables

The independent variables are categorized as firm characteristics, investor characteristics and market condition. Each independent variable is collected and then transformed into monthly basis, starting from the date the company was founded until a specific event occurs.

4.2.1 Firm characteristics

To reduce unobserved heterogeneity, we follow previous studies (e.g., Ozmel, Robinson and Stuart (2013)) and use patents to control for firm quality[9]. Hsu and Ziedonis (2008) find that patents can signal a positive indication of quality to investors and thereby increase the probability of an IPO. If we do not control for firm quality in our analysis, our regression may suffer from omitted variable bias. Patent application dates have been collected manually for each company from the United State Patents and Trademark Office (USPTO) patent database. The total number of patent applications were then accumulated during the past five years. We collected a total of 9,901 patent application dates. We noticed that 46 of the companies' patent fillings were conducted before the foundation dates. These patent applications were set to zero.

[9] Patents is a weak proxy for firm quality, since one detailed patent could be better than 10 weakly specified. Also, more patent applications could be due to the lack of confidence in single projects. With this said, patent remains the most widely accepted proxy for firm quality in the literature, therefore we choose not to elaborate with alternative proxies.

As a second measure, we include the number of strategic alliances during the past five years for the period 1965-2016[10]. As shown in Stuart, Hoang and Hybels (1999), alliance operates as firm quality, signaling reduced uncertainty about the firm to the public. Private biotechnology companies with salient alliances go to IPO faster than companies that lack such connection.

The last firm quality measurement is "location", which is a dummy variable indicating if a company is based in Massachusetts or California. We incorporate it to control for the possible geographical effect, as Lerner (1995) argues that it is an essential determinant of access to venture capital.

4.2.2 Investor characteristics

We incorporate the number of financing rounds each firm has received in month *t* and the accumulated funding amount by measuring the equity amount invested. We then create a dummy variable, indicating if a company is financed by both VC and public investors or only by venture capitalists.

We follow Ozmel, Robinson and Stuart (2013) and use the centrality measure developed by Bonacich (1972) to measure the influence of venture capital and public investments. According to Hochberg, Ljungqvist and Lu (2007), better networked VCs are more likely to experience a successful exit through an IPO or a M&A. The eigenvector centrality method accounts for the quality of the connections (i.e. investing firms) each company has, defined by how important each tie is (Hochberg, et al., 2007). The eigenvector centrality is defined as:

$$c_{i,t} = \frac{1}{\lambda}\sum_{j=1}^{N_t} A_{i,j,t}\, c_{j,t} \qquad (4.1)$$

where λ is a normalizing parameter defined as the maximum number of connections and N_t indicates the total number of active investing firms between *t - 5* and *t*. The adjacency matrix $A_{i,j,t}$ shows the number of co-investments between firms *i* and *j* between *t -5* and *t*. $c_{j,t}$ is the centrality of the investing firm at month *t*. For robustness purposes, we incorporate another measure of centrality, defined as degree centrality. Degree and eigenvector (or closeness) centrality differ in the way that the degree centrality method only calculates the number of

[10] The alliance variable was included from the study by Johansson & Fardell (2017). The reason for why we have not included the last 2 years is due to the limited information sources.

connections and not the quality of the same (Hochberg, et al., 2007). Details about how the centrality measures are constructed can be found in the Appendix.

Lastly, we follow Gompers and Lerner (2000) and incorporate the variable “firm age”, indicating the average time measured in months between the company founded date and the first investment received. Previous studies by Dai (2007) and Lerner, Chernenko and Zeng (2017) find that public investors tend to invest in later stages. It is particularly important to include “firm age” as a control variable to capture any effect on the exit event that may arise from the increasing quality of the company over time. By including this variable, it is less likely that the results will be biased due to the difference in the time of investment between venture capitalists and public investors.

4.2.3 Market condition

To control for the overall equity market conditions, we use the Standard & Poor’s 500 3-month index return. As it is evident in the biotechnology industry, venture capitalists have the flexibility to time IPO when equity values are high as financing is provided in stages. This makes the IPO activity positively correlated with high equity valuations (Lerner, 1994). For robustness purposes, we use the S&P500 1-month and 6-month returns. We also replace the S&P500 index with the Nasdaq index return (CCMP), using 1-month, 3-months and 6-months returns. To control for the biotechnology market conditions, we incorporate the Nasdaq Biotechnology Index (NBI) using 1-month, 3-months and 6-months returns. The reason for using NBI for robustness purposes and not as our main index is that it is only existing from 1993 and onwards. The regression is not tabulated, due to its many missing observations.

4.3 The pricing of IPO

To study whether there is any difference in the pricing of IPOs between companies that have received public and private investments, we collect data to examine price revisions for the IPO sample from the SEC website. Since start-ups have recently started to receive increased investments from public market players, we narrow the sample by only collecting data for the companies that made an exit between the time period 2010–2018. This gives us a final sample of 227 companies, where 152 companies are VC-backed, and 74 companies are public-backed.

The first set of tests examine the valuation at IPO for the IPO sample. The dependent variable "pre-money" is computed as the number of shares held by existing shareholders times the IPO price. In the appendix we tabulate the results for three other set of tests. The first dependent variable "absolute price revision" is computed as the change between the IPO price and the mid-point of the filing range (Loughran and McDonald, 2013). The second dependent variable "step-up multiple" is the revision in the price, computed as the difference between the last private financing round and the mid-point of the filing range (Jeppsson, 2018). The third dependent variable "up-revision" is computed as the difference between the final price in the 424 filing and the mid-point of the S-1/A filing[11]. The variable is calculated in the following way: $\frac{IPO\ price}{S-1/A\ price} - 1$, if IPO price > S-1/A price, otherwise 0.

In terms of independent variables, we include the variables mentioned before. Furthermore, following other studies such as Loughran and Mcdonald (2013) and Jeppsson (2018) we collect data and include control variables that have an influence on the IPO pricing. As investor characteristics, we include a board dummy indicating if the lead investor[12] (public or private investor) has at least one board position in the nascent company. We also include the dummy "geography", indicating if the lead investor and the private company are located in the same state. Furthermore, we control for the IPO condition by collecting the number of conducted IPOs 3 months prior to the IPO date. Following the study by Jeppsson (2018) we lag the IPO condition variable by one quarter. This is done to allow the company to prepare for an exit through an IPO. As company and issue characteristics we include several variables. We construct the rank dummy in the same way as Carter and Manaster (1990). The variable takes a value of 1 if the lead underwriter[13] has a ranking score of 8 or more, else 0[14]. Inspired by Jeppsson (2018) we also incorporate the variable "company age", measured as the natural logarithm value of the difference between the date of foundation and the IPO date plus unity. The variable "issue size" is computed as the number of shares issued times the IPO price, measured in millions of dollars. Lastly, we incorporate the variable "days424", measured as

[11] S-1/A filing refers to the mid-point of the process of going public. 424 filing refers to the final prospectus. For more information about the filing process, see figure A.2 in the appendix.
[12] The lead investor is defined as the investor with the biggest share in the private company.
[13] The lead underwriter is defined as the underwriter main responsible for the prospectus.
[14] The data was obtained from professor Jay Ritter's website https://site.warrington.ufl.edu/ritter/ipo-data/. For the years 2012-2018, we used the score ranking from 2011.

the log value of days between the S-1/A filing and the 424 filing. A summary statistic is displayed in table 4.4 below.

Table 4.4: Descriptive statistics - hypothesis 2
Table 4.4 provides descriptive statistics for the dependent and the independent variables. The variables are defined in the data section. [15]

	Only VC					VC and/or public investors				
Variable	Mean	Std	25th	Median	75th	Mean	Std	25th	Median	75th
Absolute price revision	0.107	0.115	0.000	0.071	0.143	0.086	0.106	0.000	0.061	0.143
Up-revision	0.026	0.046	0.000	0.000	0.063	0.034	0.056	0.000	0.000	0.063
Step-up multiple	0.836	1.166	0.194	0.518	1.022	1.093	1.419	0.156	0.587	1.366
Pre-money	311.108	624.205	101.746	187.203	327.63	372.477	504.721	169.397	283.969	419.691
Geography	0.711	0.455	0.000	1.000	1,000	0.784	0.414	1.000	1.000	1.000
Avgfirmage	29.33	8.73	24.777	28.756	33.329	29.504	7.045	26.5	29.668	33.967
Total funding (million USD)	115.152	151.272	59.832	94.253	131.939	140.073	89.599	83.534	117.789	171.457
Issue size	85.387	64.056	54.094	71.75	101.78	108.366	108.547	70.015	90.000	120.000
Rankdummy	0.533	0.501	0.000	1.000	1.000	0.635	0.485	0.000	1.000	1.000
SP5003	0.034	0.041	0.015	0.032	0.055	0.025	0.046	-0.003	0.029	0.054
IPOcond	8.184	5.614	4.000	7.000	11.000	7.689	3.867	4.000	7.000	10.000
Board dummy	0.93	0.257	1.000	1.000	1.000	0.095	0.295	0.000	0.000	0.000
Company age	2.104	0.552	1.764	2.155	2.524	2.065	0.624	1.682	2.085	2.526
Centrality	0.162	0.105	0.102	0.144	0.192	0.172	0.092	0.114	0.164	0.211
Days424	1.537	1.059	0.693	1.701	2.303	1.648	1.23	0.693	1.792	2.303
DaysS1A	3.824	0.887	3.178	3.481	4.562	3.47	0.743	3.045	3.332	3.67
Ranking	5.925	3.594	3.001	8.001	9.001	6.676	3.328	6.376	8.251	9.001
SP5001	0.011	0.032	-0.004	0.014	0.031	0.01	0.034	-0.005	0.009	0.035
NASDAQ1	0.014	0.039	-0.012	0.023	0.038	0.015	0.039	-0.015	0.021	0.049
NASDAQ3	0.045	0.051	0.018	0.058	0.075	0.038	0.055	0.021	0.057	0.077
Price revision	-0.052	0.149	-0.131	0.000	0.067	-0.018	0.136	-0.059	0.000	0.063

Table 4.5: Correlation matrix with pre-money as the dependent variable
Table 4.5 shows the correlation between the dependent and the independent variables. The numbers in the top row correspond to the labeled covariates in the first column.

	1	2	3	4	5	6	7	8	9	10	11	12
1. Pre-money (million USD)												
2. VC/Public investor	0.05											
3. Geography	0.001	0.078										
4. Avgerage firm age	0.041	0.01	0.022									
5. Total funding (million USD)	0.739***	0.087	0.134**	0.161**								
6. Issue size	0.826***	0.132**	-0.057	-0.016	0.464***							
7. Rank dummy	0.002	0.097	0.121*	0.188***	0.061	0.041						
8. SP5003	-0.226***	-0.089	0.042	-0.066	-0.226***	-0.137**	0.005					
9. IPO condition	0.017	-0.046	0.064	0.103	0.039	-0.01	0.018	-0.057				
10. Board dummy	-0.042	-0.827***	-0.08	-0.05	-0.047	-0.106	-0.08	0.03	0.07			
11. Days424	-0.074	0.047	-0.09	-0.06	-0.063	-0.101	0.024	0.043	0.008	0.044		
12. Company age	0.035	-0.032	0.046	-0.064	0.083	-0.023	-0.134**	0.207***	0.003	0.1	-0.048	
13. Centrality	-0.065	0.047	0.002	0.16**	-0.05	-0.061	0.009	-0.073	0.091	-0.052	0.027	-0.205***

In the correlation matrix above, we observe a remarkably high correlation between the pre-money variable and total funding and issue size (0.739 and 0.826 respectively). Both variables are significant on a 1% significance level. On the contrary, the S&P 500 variable is negatively statistically correlated with the pre-money variable. This is unexpected since more favorable market conditions should result in a higher IPO valuation. If the IPO price is higher under favorable market conditions, the pre-money variable should also be higher, all else equal. We also note that VC/public investor and the board dummy are highly negatively statistically

[15] We perform t-tests for all our dependent variables. None of the tests result in significant values. The tables can be found in the appendix.

significant (-0.827). This is in accordance with our expectations, indicating that public investors are generally not requesting a board position even when they are the lead public investor. Unsurprisingly, we observe a high positive correlation between issue size and total funding, significant on a 1% significance level.

5. Results and analysis

In this section we present the results connected to our hypothesis, covering the probability of different exit events conditioned on the source of capital. Sections 5.1 – 5.4 are related to our first hypothesis.

5.1 Test of proportional hazard assumption

We start our analysis by conducting a test of the proportional hazard assumption. The test is performed to detect any time-variation within the variables. All variables that are significant on a 5% significance level are then included as control variables in our Cox regressions but will not be reported in the tables. We perform the same tests for the robustness section. The results are tabulated in the Appendix. From table 5.1 it can be seen that "sum of alliances last five years" and "funding rounds" violate the proportional hazard assumption. Therefore, we will include time-varying variables for these two parameters. Hancock and Mueller (2010) argue that the use of interaction terms is a diagnostic test as well as a mechanism to control for the time-varying effect.

Table 5.1: Test of proportional hazard assumption
The below table displays the outcome from the proportional hazard assumption test. All our variables are interacted with time to see whether their impact on the probability of exit changes over time. If the proportional hazard assumption holds, the effect should not be dependent on time.

	(1)
Public Investor	1.003*
Firm Characteristics	
Sum of patents, last five years	1.000
Sum of alliances, last five years	0.995***
Location	0.999
Investor Characteristics	
Funding Rounds	0.999***
Accumulated amount invested	1.000
Firm age	1.000
Centrality Degree	1.000
Market Conditions	
S&P500 return, 3 months	1.000
Number of observations	253 312
Number of companies	2 225

5.2 Exit probability through IPO and M&A

In table 5.2 we study the effect of different risk capital on the probability of exiting through IPO or M&A, controlling for the variables mentioned in the data section. The first regression only includes the public investor dummy. Control variables are then added to the regression until reaching the fully specified model in column 4[16].

Table 5.2: Hazard estimates where IPO and M&A are the outcomes of interest

M&A is defined as pure acquisitions, where partial acquisitions, mergers, LBOs and pending acquisitions have been excluded. The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by both VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Eigenvector centrality controls for the relative network positioning the risk capital investor has. S&P500 return, 3 months is a return index, capturing the market conditions for a given month. To strengthen the results section, all our regressions have been executed with robust standard errors.

	(1)	(2)	(3)	(4)
Public Investor	1.585***	1.465***	1.219**	1.222**
Firm Characteristics				
Sum of patents, last five years		1.022***	1.004	1.004
Sum of alliances, last five years		1.869***	1.849***	1.844***
Location		1.364***	1.121*	1.120*
Investor Characteristics				
Funding Rounds			1.310***	1.310***
Accumulated amount invested			1.002***	1.002***
Firm age			1.000*	1.000*
Centrality			1.006*	1.006*
Market Conditions				
S&P500 return, 3 months				1.014***
Number of observations	260 175	260 175	253 351	253 312
Number of companies	2 227	2 227	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively. [17]

Once controlling for investor characteristics, the patent variable becomes insignificant. A strategic alliance increases the probability of exit by 84.4%, which is statistically significant on a 1% significance level. This is in line with the findings in Ozmel, Robinson and Stuart (2013) and

[16] Unless exclusively stated, we will always refer to the fully specified model (column 4) when interpreting our findings.

[17] The number in parenthesis, ranging from 1 to 4, each representing a unique regression.

the study by Stuart, Hoang and Hybels (1999). Consistent with Lerner (1995), the location of the company is significant on a 10% significance level. Companies with more financing rounds are more likely to exit. The variable is highly statistically significant, where each additional financing round increases the probability of an exit by 31%. The results are supported by the findings in Ozmel, Robinson and Stuart (2013). The variable "accumulated amount invested" is also statistically significant on 1% significance level. Firm age and centrality are significant on a 10% significance level. A higher centrality is positively correlated with an exit. Hochberg, Ljungqvist, and Lu (2007) get similar findings. Finally, we observe that the variable "S&P500 3-months return" has a positive impact on the likelihood of an exit, significant on a 1% significance level. One unit increase in the S&P500 3-months return increases the probability of an exit by 1.4%. In line with our findings, Lerner (1994) and Ball, Chiu and Smith (2011) observe that companies tend to go public when there are favorable market conditions.

According to the above findings, start-up companies financed by both VC and public investors experience a higher probability of exit than start-up companies financed by venture capitalists. When "firm characteristics", "investor characteristics" and "market conditions" are included, the public investor dummy becomes less significant, but still indicating a positive impact on the probability of exit. After adding the control variables, companies backed by VC and public investors experience 22.2% higher probability of an exit, statistically significant on the 5% significance level. The fact that the result is still significant when adding the control variables, and in particular those related to investors characteristics, indicates that our findings are not due to differences in the investment strategies. One major concern from the beginning was that the differences in probability of exit would disappear when controlling for the timing of the investment and in what round the players were entering. We also rerun the regression including an interaction variable between the centrality measure and the public investor dummy, to ensure that our result is not a consequence of public investors just co-investing with the most prominent VC investors. This regression is untabulated since the interaction variable is insignificant, without affecting the other variables substantially, demonstrating that the probability of exit will not change over time as a function of the quality of VC investors. As already mentioned in the data section, we will also perform the propensity score matching procedure, to cement our findings. From the above information we find support to our first hypothesis.

5.3 Exit probability through IPO

When defining exit events as either IPO or M&A, we are facing the risk of heterogeneity, since exiting through IPO is generally more profitable (Brau, Francis, and Kohers 2003; Bienz and Leite 2008; Gompers and Lerner 1997). To overcome this problem, we run two different regressions. First with IPO and then with M&A as the variable of interest.

Table 5.3 presents the hazard estimates for exits through an IPO. The public investor dummy is highly statistically significant and has an even more positive impact on the probability of going public. Companies backed by VC and public investors experience a 60.5% higher probability of exiting through an IPO. In contrast to the hazard estimates from table 5.2, the patent variable is significant on a 10% significance level in the fully specified model. An additional patent application filed over the last 5 years increases the probability of exit by 1.3%. This is in line with the study of Hsu and Ziedonis (2008), who find that patents increase the probability of an IPO. The alliance variable remains highly statistically significant, increasing the probability of an exit with 88.6%. Location is still significant on a 10% significance level. Funding rounds and accumulated amounts continue to be highly significant (p-value<0.01). When the exit event is restricted to only include IPOs, firm age and centrality become statistically insignificant. As before, market condition has a positive impact on the probability of exit through an IPO, significant on the 1% significance level.

Table 5.3: Hazard estimates with IPO as the event of interest
The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit, the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Eigenvector centrality controls for the relative network positioning the risk capital investor has. S&P500 return, 3 months is a return index, capturing the market conditions for a given month. To strengthen the results section, all our regressions have been executed with robust standard errors.

	(1)	(2)	(3)	(4)
Public Investor	2.273***	1.985***	1.598***	1.605***
Firm Characteristics				
Sum of patents, last five years		1.031***	1.013*	1.013*
Sum of alliances, last five years		1.905***	1.888***	1.886***
Location		1.517***	1.186*	1.184*
Investor Characteristics				
Funding Rounds			1.356***	1.354***
Accumulated amount invested			1.003***	1.003***
Firm age			1.000	1.000
Centrality			1.007	1.007
Market Conditions				
S&P500 return, 3 months				1.029***
Number of observations	260 175	260 175	253 351	253 312
Number of companies	2 227	2 227	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

5.4 Exit probability through M&A

The hazard estimates with M&A as the variable of interest are tabulated in table 5.4. In contrast to the previous regressions, we do not observe a statistically significant relationship between the public investor dummy and the probability of exit through M&A. Patents, alliances, location, centrality and S&P500 3-months return are all statistically insignificant. Funding rounds remain statistically significant at a 1% significance level whereas accumulated amounts and firm age are statistically significant on 5% respectively 10% significance level. One more funding round increases the probability of an exit through M&A by 24.8%.

Table 5.4: Hazard estimate with M&A as the event of interest
M&A is defined as pure acquisitions, where partial acquisitions have been excluded. The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit, the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Eigenvector centrality controls for the relative network positioning the risk capital investor has. S&P500 return, 3 months is a return index, capturing the market conditions for a given month. To strengthen the results section, all our regressions have been executed with robust standard errors.

	(1)	(2)	(3)	(4)
Public Investor	0.908	0.931	0.816	0.816
Firm Characteristics				
Sum of patents, last five years		0.999	0.971	0.971
Sum of alliances, last five years		1.935	1.804	1.804
Location		1.224**	1.066	1.066
Investor Characteristics				
Funding Rounds			1.248***	1.248***
Accumulated amount invested			1.001**	1.001**
Firm age			1.001*	1.001*
Centrality			1.005	1.005
Market Conditions				
S&P500 return, 3 months				1.000
Number of observations	260 175	260 175	253 351	253 312
Number of companies	2 227	2 227	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

The patent variable is statistically significant for the probability of going public, but not when exiting through M&A. This is in line with Ozmel, Robinson and Stuart (2013). In their study, exiting through IPO results in more variables with significant impact on the exit event, while most variables are statistically insignificant when exiting through M&A. One possible explanation for the negative (but insignificant) relation between public investment and the probability of undergoing an acquisition is the difference in objectives between a VC investor and a public investor. According to Dai (2007), VCs tend to keep their positions longer, get a significant ownership and request board seats, whereas public investors have a short investment horizon. A second explanation as provided by Danzon, Epstein, and Nicholson (2007) could be that small companies which are acquired are often a result of trouble. Therefore, an exit through M&A is not necessarily a successful outcome. In support of this finding Ozmel, Robinson and Stuart (2013) notice that M&A is a noisier measure of success. Finally, VCs are more involved in the companies they invest, compared to public investors. For this reason, companies backed by VCs could be more attractive to potential acquirers, but due to the noisiness in the data we refrain from making any inference on what causes the exit through M&A.

5.5 Discussion

The difference in exit outcomes is mainly driven by the hazard of IPOs. Companies supported by public investors increase the hazard of exit through IPO but not through M&A. When treating either of the exit events as successful outcomes, we still observe a significant difference on the probability of exit. Since the public investments primarily raise the hazard of going public, it is possible that public investors are more successful investors than venture capitalists, since IPO is generally considered to be a more favorable outcome (Brau, Francis, and Kohers 2003; Bienz and Leite 2008; Gompers and Lerner 1997). It could also indicate that public investors tend to seek short term profits to a greater extent than VCs.

5.6 Pre-money valuation

In table 5.5 we study the difference in IPO valuation between the two different risk capitalists. The coefficients of different regressions with pre-money as the dependent variable are presented in the table below. In column 5, we conduct a two stage least square regression as a way of further control for self-selection bias and endogeneity problems. After all, the choice (and timing) to invest in private companies is an endogenous choice made by the risk capitalist.

Table 5.5: Regressions with the pre-money variable as the dependent variable
*The dependent variable pre-money is defined as the number of shares held by existing shareholders times the price in the initial public offering. Public investor is a dummy variable taking the value of 1 if the private company is backed by VC and public investors, otherwise 0. The average firm age variable measures the average number of years between the IPO date and the founding date of the risk capitalists. Geography is a dummy variable taking the value of 1 if the lead risk capitalist is located in the same state as the private company, 0 otherwise. Board dummy is a dummy variable taking the value of 1 if the lead public investor (in case of public investment) or the lead VC investor (in case the company is solely backed by venture capitalists) has at least one board position, 0 otherwise. SP5003, controls for the 3-month SP500 index return, accounting for the market condition. IPO condition reflects the number of conducted IPOs 3-months prior to the IPO date, and is later lagged with one quarter before entering the regression. Rank dummy is a dummy variable taking the value of 1if the lead underwriter has a ranking score of 8 or more, 0 otherwise. The centrality variable ensures that the quality of the investor is taken into account. We use the eigenvector centrality, which as stated before, incorporates the quality of connections between investors and not just the quantity. Company age is measured as the natural logarithm of unity plus the company age in years (IPO date – date of incorporation). Total funding is the total amount of investment received (in millions USD) prior to the IPO. Issue size is the expected amount to be received in the IPO (Number of shares issued*IPO price). Days424 is the logarithmic value of the number of days between the S-1/A filling and the 424 filling (log(424-S-1/A)).*

	OLS	*OLS*	*OLS*	*OLS*	*2SLS*	*OLS*
Pre-money	(1)	(2)	(3)	(4)	(5)	(6)
Public investor	-87.6630**	-125.8077***	-115.4217**	-125.5538***	-61.5780	14.7298
Investor Charaterisics						
Average firm age		-1.6758	-1.6471	-1.7253	Yes	2.8336
Geography		-7.2696	-11.4168	-7.7984	Yes	-2.9091
Board dummy		-51.8133	-45.9175	-52.4742	Yes	-34.8421
Market and IPO conditions						
SP5003	-649.5052	-661.4644		-654.7327	-612.5551	-3199.719
IPO condition			1.2179	0.9058	0.7509	1.1831
Company and issue charateristics						
Rank dummy	-46.3010	-43.2356	-46.6373	-43.1916	-49.3735	5.0189
Centrality	14.8192	-44.7585	-36.4532	-48.4423	-70.9783	-375.3209
Company age	10.0957	6.4188	-6.4707	6.0119	5.9242	73.6709
Total funding (million USD)	1.9220***	1.9615***	2.013	1.9612***	1.9325***	
Issue size (million USD)	4.443***	4.4183***	4.4191	4.4184***	4.4319***	
Days424	12.3295	9.6335	7.6349	9.4140	9.5398	-29.3618
Constant	-287.6523	-171.7359	-183.2576	-175.3053	-277.8422	311.085
Number of observations	218	215	215	215	215	215
R^2	0.8529	0.8551	0.8531	0.8552	0.8516	0.0669
F-value	26.69	20.16	20.36	18.31	23.15	1.48
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.1501

*, ** and *** denote statistical significance at the 10, 5 and 1 percent level, respectively

In the fully specified model (column 4), the public investor dummy is highly negative and statistically significant on a 1% significance level. Thus, our second hypothesis is supported. However, when running a two stage least squares regression (column 5), we no longer observe a statistical difference among the risk capitalists. We follow the study by Jeppsson (2018) and use firm age, geography and the board dummy as instrument variables[18]. Also, as noted by Jeppsson (2018) and Habib and Ljungqvist (1998), it is not obvious that issue size should be controlled for since a decrease in issue size is most likely a consequence of a decrease in the price revision. Habib and Ljungqvist (1998) also show that underpricing

[18] A test of the validity of instruments is reported in table A.14 in the appendix.

strictly decreases as a factor of issue size. Rerunning the regression from column 4 but excluding the total funding and issue size variables (column 6), again results in an insignificant result for the public investor dummy variable. Therefore, we would highlight the importance of interpreting these findings with caution.

From the results connected to our second hypothesis there seems to be no certification effect from public investments. Almost all the results are insignificant, and the explanatory power of our regressions are low for all regressions where issue size and total funding are excluded[19]. This suggest that our models/regressions cannot very well explain the differences for the dependent variables. Therefore, it is still possible that there is a certification effect connected to public investments, which we are unable to capture. Yet we have followed methods from previous studies and used the same control variables and therefore we decide to still report our results.

Given that our fully specified regression (table 5.5, column 4) provides accurate results, one potential explanation could be found in the paper of Brophy, Ouimet and Sialm (2006). They find that hedge funds act as investors of last resort by investing in young risky companies with severe information asymmetry. In return, they ask for substantial discounts to compensate for the high risk. These results are similar to the observations made by Dai (2007). Thus, our findings related to the two hypotheses could be explained by the desire small private companies have to go public and be able to reach out to a broader audience, when raising capital. On the other hand, there seems to exist an illiquidity premium, thereby making it possible for public investor to enjoy abnormal returns, when taking private companies public (Hagströmer, Hansson and Nilsson, 2013; Amihud, Hameed, Kang and Zhang, 2015). The illiquidity premium could explain the growing trend of public investments in private biotech companies. However, since our definition of public investors includes hedge funds, mutual funds and pension funds, it is difficult to conclude whether our results are a consequence of hedge funds' investment habits or if there are other explanations. Although hedge funds are typically referred to as short term/opportunistic investors, that is not the case for mutual and pension funds. They tend to invest for the long term. Due to our data set, it is not possible to separate these investor types, to conduct a sub-analysis. Thus, our inference for the second hypothesis will be limited to the speculative explanations above.

[19] We get similar results when we only exclude the issue size variable. Therefore, we choose not to report those results.

6. Robustness Considerations

6.1 Propensity score matching

Potential critique to our results in tables 5.2-5.4 could be related to previous findings that public investors tend to invest in a later stage, when the company is close to go public or get acquired. Then one could argue that the results would be a consequence of such investment habits. However, the results in table 6.1 support our first hypothesis. After we have matched the control variables patents, alliance, location, firm age, centrality and SP500 3-months return, we still obtain a difference in the probability of exit, between the two different sources of capital (VC and public investments). The difference is significant on the 1% significance level (t-value 18.19), indicating that receiving capital from VC and public investors increase the probability of an exit compared to only receiving capital from venture capitalists.

Table 6.1: Propensity score matching
In table 6.1 we perform a single nearest neighbor matching procedure[20], to be able to compare the difference in probability of exit, as a function of the risk capital received. The control variables included in the probit regression are patents, alliance, location, firm age, centrality and S&P500 3-months return. The reason for excluding funding rounds and accumulated amounts invested is because our matching would then be unbalanced (this is controlled for in the t-test in table 6.3).

Public investor	**Probit**
Firm Charaterisics	
Sum of patents, last five years	-0.002
Sum of alliances, last five years	0.179***
Location	0.294***
Investor Charaterisics	
Firm age	0.000***
Centrality	-0.000
Market Conditions	
S&P500 return, 3 months	-0.000
Constant	-1.436
Number of observations	259 679

*, ** and *** denote statistical significance at the 10, 5 and 1 percent level, respectively

Variable	***Sample***	***Treated***	***Control group***	***Difference***	***t-value***
Exit (IPO or M&A)	*Unmatched*	0.803	0.591	0.212	41.97
	Matched	0.803	0.633	0.170	18.19

[20] We also performed a one-to-five matching procedure (one treatment unit is matched against five comparison units) which gave similar results. Therefore, these results are untabulated.

Table 6.2: Common support
There is a high level of common support (the propensity scores of the treatment group (VC- and public-backed companies) are generally aligned with the propensity scores of the untreated group (VC-backed companies)).

Treatment assignment	Common support on suport	Total
Untreated	*230 738*	*230 738*
Treated	*28 941*	*28 941*
Total	***259 679***	***259 679***

6.1.1 Evaluation of matching procedure

From table 6.3 it is evident that all the different t-tests are insignificant on a 1-,5- and 10-percent significance level. In addition, none of the biases are higher than 5 percent. This means that the covariates are accurately balanced, thereby increasing the confidence when making inferences about the nearest neighbor matching.

Table 6.3: Evaluation of the matching procedure using t-test
Table 6.3 displays the t-test, which is used to evaluate the quality of our nearest neighbor matching (i.e. whether the covariates are balanced or not).

	Mean				
Variable	**Treated**	**Control**	**% Bias**	**t-value**	**p-value**
Sum of patents, last five years	0.421	0.407	0.5	0.710	0.479
Sum of alliances, last five years	0.161	0.166	-1.0	-0.920	0.360
Location	0.620	0.616	0.6	0.780	0.436
Firm age	212.56	213.24	-0.4	-0.520	0.600
Centrality	10.667	10.786	-1.1	-1.380	0.166
S&P500 return, 3 months	1.774	1.832	-0.8	-0.940	0.345

6.2 Exit probability with alternative M&A

Table 6.4 reports the hazard estimates for exits though IPO or M&A. As a test of how robust our results are to different definitions of the M&A-exit variable, we now redefine M&A to include acquisitions, pending acquisitions, mergers and LBO. All the variable estimates are close to the estimates observed in the original regression (table 5.2). All the variables have the same significance level.

Table 6.4: Exit through IPO or M&A – alternative event

Table 6.4 is constructed in the same way as table 5.2, except for the M&A event. In this regression we have redefined the second event to include exits such as acquisitions, pending acquisitions merger and LBO. The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit, the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Eigenvector centrality controls for the relative network positioning the risk capital investor has. S&P500 return, 3 months is a return index, capturing the market conditions for a given month. To strengthen the results section, all our regressions have been executed with robust standard errors.

	(1)	(2)	(3)	(4)
Public Investor	1.603***	1.486***	1.237**	1.240**
Firm Characteristics				
Sum of patents, last five years		1.023***	1.005	1.005
Sum of alliances, last five years		1.827***	1.820***	1.815***
Location		1.359***	1.118*	1.117*
Investor Characteristics				
Funding Rounds			1.302***	1.301***
Accumulated amount invested			1.002***	1.002***
Firm age			1.000*	1.000*
Centrality			1.006*	1.006*
Market Conditions				
S&P500 return, 3 months				1.014***
Number of observations	260 175	260 175	253 351	253 312
Number of companies	2 227	2 227	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

Testing for alternative M&A as the event of interest, we do not see any dramatical differences from the original specification. The results can be found in the Appendix (table A.7). The variables public investor dummy and alliances have a bit lower (but still positive) impact, compared to the regression where only pure acquisitions were included. However, they still have the same significance level, so it is not possible to draw any scientific conclusions about the divergence. The only variable that differs in terms of statistical significance is the accumulated amount invested, which has now become statistically insignificant. The alternative M&A definition appears to be fairly robust, both when the exit event includes IPO and M&A or just M&A.

6.3 Alternative index specifications

Using alternative S&P500 index return measures, the hazard estimates are still robust. The only variable which is affected significantly is the S&P500 return variable. When the market return is calculated using 1-month interval, the parameter is significant on a 5% significance level. For the 3- and 6-months intervals, S&P500 becomes statistically significant on a 1% significance level. Switching to the NASDAQ index return (CCMP), we get similar results as those observed using the S&P500 index return. The NASDAQ index return is the only variable that has changed its significance level. For this market condition proxy, there is no significant impact when the return is measured monthly. When 3-months and 6-months return intervals are used, the NASDAQ variables become significant on a 1% significance level.[21]

6.4 Average hazard estimates

As an alternative approach to the regression including interaction terms, we now exclude all the time-interacting variables. The results are available in table 6.5. All the covariates with significant time-varying variables (alliances and funding rounds) are affected negatively. These parameters have a lower effect on the probability of exiting through an IPO or M&A. This is because the estimates in the proportional hazard assumption test are lower than one and statistically different. This essentially means that alliances and number of funding rounds are more important for young and small nascent companies than for older ones. If the hazard values would have been statistically greater than one, the opposite had been true. We observe a similar pattern for the exits through IPO and M&A separately.

[21] For further details about the results, see the Appendix.

Table 6.5: Average Hazard estimates

Average hazard estimates where IPO and/or M&A is/are the event(s) of interest. In this specification there are no time-interacting variables. The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Eigenvector centrality controls for the relative network positioning the risk capital investor has. S&P500 return, 3 months is a return index, capturing the market conditions for a given month. To strengthen the results section, all our regressions have been executed with robust standard errors.

	IPO or M&A (1)	IPO (1)	M&A (1)
Public Investor	1.224**	1.639***	0.808
Firm Characteristics			
Sum of patents, last five years	1.003	1.012*	0.970
Sum of alliances, last five years	1.180***	1.339***	0.577*
Location	1.136*	1.204*	1.075
Investor Characteristics			
Funding Rounds	1.132***	1.176***	1.103***
Accumulated amount invested	1.002***	1.003***	1.001**
Firm age	1.001**	1.000	1.001*
Centrality	1.008**	1.009*	1.006
Market Conditions			
S&P500 return, 3 months	1.014***	1.029***	1.000
Number of observations	253 312	253 312	253 312
Number of companies	2 225	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

6.5 Degree centrality

In table 6.6, we change the centrality measure from eigenvector centrality to degree centrality to account for the number of network connections rather than the quality. The results are robust to the original regression. For the exit through IPO and M&A "firm age" has become significant on a 5% significance level instead of the previous 10% level. Centrality is now insignificant. When we only consider IPO exits, none of the hazard estimates have changed statistically. For the M&A specifications, we observe the same significance levels for all variables except "firm age", which has now changed from 10% to 5% significance level.

Table 6.6: Degree Centrality

Table 6.6 is based on the same regressions as in tables 5.2-5.4, with the only difference in how the centrality variable is measured. In this regression we have replaced the eigenvector centrality measurement in favor of the Degree Centrality measure. The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Centrality degree controls for the number of connections each company has. S&P500 return, 3 months is a return index, capturing the market conditions for a given month. To strengthen the results section, all our regressions have been executed with robust standard errors.

	IPO or M&A	IPO	M&A
	(1)	(1)	(1)
Public Investor	1.221**	1.606***	2.018**
Firm Characteristics			
Sum of patents, last five years	1.003	1.013*	0.971
Sum of alliances, last five years	1.853***	1.897***	1.812
Location	1.129*	1.199*	1.067
Investor Characteristics			
Funding Rounds	1.312***	1.359***	1.245***
Accumulated amount invested	1.002***	1.003***	1.001**
Firm age	1.001**	1.001	1.001**
Centrality degree	1.001	1.000	1.002
Market Conditions			
S&P500 return, 3 months	1.014***	1.029***	1.000
Number of observations	253 312	253 312	253 312
Number of companies	2 225	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

6.7 Robustness considerations for the pre-money variable

Table 6.7 below is based on the same variables as in table 5.5. The only difference is how the index returns are specified. We replace the S&P 500 3-months return by S&P 500 1-month and the NASDAQ 1- and 3-months return. The three first regressions are the fully specified models, with the replaced indexes. The variable of interest, public investor dummy, remains negatively statistically significant. As for the regressions 4 – 6 which correspond to the regressions without total funding and issue size, the results appear robust compared to the previous regressions.

Table 6.7: Robustness check concerning the pre-money variable

*The dependent variable pre-money is defined as the number of shares held by existing shareholders times the price in the initial public offering. Public investor is a dummy variable taking the value of 1 if the private company is backed by VC and public investors, otherwise 0. The average firm age variable measures the average number of years between the IPO date and the founding date of the risk capitalists. Geography is a dummy variable taking the value of 1 if the lead risk capitalist is located in the same state as the private company, 0 otherwise. Board dummy is a dummy variable taking the value of 1 if the lead public investor (in case of public investment) or the lead VC investor (in case the company is solely backed by venture capitalists) has at least one board position, 0 otherwise. SP5003, controls for the 3-month SP500 index return, accounting for the market condition. IPO condition reflects the number of conducted IPOs 3-months prior to the IPO date, and is later lagged with one quarter before entering the regression. Rank dummy is a dummy variable taking the value of 1if the lead underwriter has a ranking score of 8 or more, 0 otherwise. The centrality variable ensures that the quality of the investor is taken into account. We use the eigenvector centrality, which as stated before, incorporates the quality of connections between investors and not just the quantity. Company age is measured as the natural logarithm of unity plus the company age in years (IPO date – date of incorporation). Total funding is the total amount of investment received (in millions USD) prior to the IPO. Issue size is the expected amount to be received in the IPO (Number of shares issued*IPO price). Days424 is the logarithmic value of the number of days between the S-1/A filling and the 424 filling (log(424-S-1/A)).*

	OLS	***OLS***	***OLS***	***OLS***	***OLS***	***OLS***
Pre-money	(1)	(2)	(3)	(4)	(5)	(6)
Public investor	-116.0806**	-116.0019**	-129.3783***	56.4903	61.2325	9.7684
Investor Charaterisics						
Average firm age	-1.7512	-1.7347	-1.7667	2.2479	2.8223	2.7787
Geography	-10.0222	-9.8311	-7.8423	0.8806	0.8960	-6.2179
Board dummy	-46.8242	-47.6063	-56.7636	-11.5763	-15.4122	-45.4955
Market and IPO conditions						
SP5001	-349.3816			-4158.418		
NASDAQ1		-331.7428			-3128.153	
NASDAQ3			-660.3122*			-2617.967
IPO condition	0.9993	0.9103	0.1213	0.1329	-0.1372	-1.6309
Company and issue charateristics						
Rank dummy	-48.782	-48.9900	-41.4346	-37.9088	-34.3182	8.9439
Centrality	-24.8148	-20.3172	-32.7190	-176.7527	-166.2413	-303.1802
Company age	-3.6557	-3.2173	8.0666	48.503	46.7764	70.5127
Total funding (million USD)	1.9983***	2.0002***	1.9525***			
Issue size (million USD)	4.4070***	4.4045***	4.4217***			
Days424	7.6000	7.3900	8.8037	-37.6310*	-39.81283**	-33.5966
Constant	-178.5923	-178.125	-161.5886	305.7041	296.4564	359.1808
Number of observations	215	215	215	215	215	215
R^2	0.8535	0.8536	0.8562	0.0633	0.0539	0.0653
p-value	0.0000	0.0000	0.0000	0.1093	0.0811	0.1729

7. Conclusions

Our thesis sheds new light on the importance of the increased participation of public investors in private companies. We investigate whether public investors have an impact on the hazard of exit in start-up companies, either through IPO, M&A or both. Our empirical analysis indicates that receiving financing from both venture capitalists and public investors results in a higher probability of a successful exit. Companies that are financed by VC and public investors experience 22.2% higher probability of an exit through IPO or M&A. We find that more financing rounds, and larger amount invested increase the probability of an exit. Furthermore, we observe that a strategic alliance and the S&P 500 3-months return have highly significant impact on the hazard of exiting successfully. Location, firm age and centrality are weakly significant. The patent variable is only significant when the companies exit through an IPO. Besides the number of financing round and the accumulated amount invested variables, we find that none of the variables have a significant impact when exiting through M&A. We further investigate whether there is any difference in the IPO valuation between VC-backed and public-backed IPOs. The findings suggest that the pre-money valuation is higher for companies that are backed by venture capitalists. However, interpretations should be made cautiously due to the findings being non-robust.

7.1 Limitations and further research

Investments from public investors in private companies is a relatively new and growing phenomenon. It would be interesting to see the effect from a study where VC investments are compared to public investments separately (when private companies receive financing from either VCs or public investors, but not both). A main drawback with our study is that it is difficult to isolate the effect of public investments from the effect of VC co-investments[22]. Given that the above-mentioned trend continues, there will be enough data to make such distinctions. Based on our findings, we suggest other master students or researchers to study the effect different risk capital sources have on underpricing, following an IPO. In addition, it would be interesting to see what impact public investments in private companies have on the stock performance after they go public.

[22] However, we have taken several steps to reduce this bias. For instance, we included centrality measures, controll for firm age and conducted a propensity score matching.

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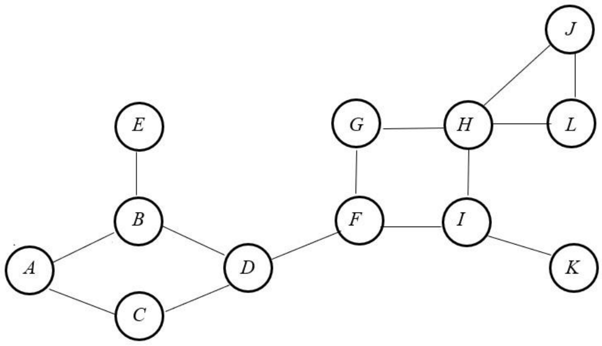
Appendix

1. Centrality

From figure A.1 below, we can see that firm H has most connections (4 connections, using the degree centrality method). H would still be assigned the highest centrality value if the eigenvector centrality measurement was used (71,86% as presented in table A.2).

Figure A.1: Centrality connections
Stylized example of a network consisting of 12 different investors. Each letter represents a unique company. The lines between the companies illustrate their connections.



Another way of displaying the different connections is through an adjacency matrix. A value of one represents a connection, while zero indicates that the corresponding companies have no cooperation. By constructing an adjacency matrix, we will be able to calculate our two different centrality measures, namely degree and eigenvector centrality. Summing each row or column and *normalizing* the value by dividing n-1 (maximum number of connections), where n is the number of companies, we arrive at the degree centrality measure. For instance, company A has two connections (with company B and C), resulting in a degree centrality of: $\frac{2}{12-1} \approx 0.1818 = 18.18\%$. Eigenvector centrality on the other hand is calculated by summing a company's connection to other companies, which is then weighted by their centralities (Hochberg, Ljungqvist and Lu, 2007). It is important to normalize the centrality values to be able to compare the centrality measures as the number of investing company changes.

Table A1: Adjacency matrix

	A	B	C	D	E	F	G	H	I	J	K	L
A	0	1	1	0	0	0	0	0	0	0	0	0
B	1	0	0	1	1	0	0	0	0	0	0	0
C	1	0	0	1	0	0	0	0	0	0	0	0
D	0	1	1	0	0	1	0	0	0	0	0	0
E	0	1	0	0	0	0	0	0	0	0	0	0
F	0	0	0	1	0	0	1	0	1	0	0	0
G	0	0	0	0	0	1	0	1	0	0	0	0
H	0	0	0	0	0	0	1	0	1	1	0	1
I	0	0	0	0	0	1	0	1	0	0	1	0
J	0	0	0	0	0	0	0	1	0	0	0	1
K	0	0	0	0	0	0	0	0	1	0	0	0
L	0	0	0	0	0	0	0	1	0	1	0	0

Table A.2: Centrality measure

Risk capitalist	Degree Centrality	Eigenvector Centrality
A	18,18%	16,34%
B	27,27%	23,23%
C	18,18%	19,89%
D	27,27%	36,17%
E	9,09%	8,80%
F	27,27%	52,35%
G	18,18%	47,06%
H	36,36%	71,86%
I	27,27%	54,94%
J	18,18%	43,83%
K	9,09%	20,82%
L	18,18%	43,83%

2. Proportional Hazard Assumption

Table A.3: Test of the proportional hazard assumption
This is the same test as the test conducted in table 5.1. The only difference is how the M&A variable is defined. M&A now includes acquisitions, pending acquisitions, merger and LBO.

	(1)
Public Investor	1.003*
Firm Characteristics	
Sum of patents, last five years	1.000
Sum of alliances, last five years	0.995***
Location	0.999
Investor Characteristics	
Funding Rounds	0.999***
Accumulated amount invested	1.000
Firm age	1.000
Centrality Degree	1.000
Market Conditions	
S&P500 return, 3 months	1.000
Number of observations	253 312
Number of companies	2 225

Table A.4: Test of the proportional hazard assumption
This is the same test as the test conducted in table 5.1. The only difference is that we now use the 1-, 3- and 6-month S&P500 index return.

	(1)	(1)	(1)
Public Investor	1.003*	1.003*	1.003*
Firm Characteristics			
Sum of patents, last five years	1.000	1.000	1.000
Sum of alliances, last five years	0.995***	0.995***	0.995***
Location	1.000	1.000	1.000
Investor Characteristics			
Funding Rounds	0.999***	0.999***	0.999***
Accumulated amount invested	1.000	1.000	1.000
Firm age	1.000	1.000	1.000
Centrality	1.000	1.000	1.000
Market Conditions			
S&P500 return, 1 month	1.000		
S&P500 return, 3 months		1.000	
S&P500 return, 6 months			1.000
Number of observations	253 312	253 312	253 312
Number of companies	2 225	2 225	2 225

Table A.5: Test of the proportional hazard assumption
This is the same test as the test conducted in table 5.1. The only difference is that we use the Nasdaq 1-, 3- and 6-month return index specifications.

	(1)	(1)	(1)
Public Investor	1.003*	1.003*	1.003*
Firm Characteristics			
Sum of patents, last five years	1.000	1.000	1.000
Sum of alliances, last five years	0.995***	0.995***	0.995***
Location	0.999	0.999	0.999
Investor Characteristics			
Funding Rounds	0.999***	0.999***	0.999***
Accumulated amount invested	1.000	1.000	1.000
Firm age	1.000	1.000	1.000
Centrality	1.000	1.000	1.000
Market Conditions			
CCMP return, 1 month	1.000		
CCMP return, 3 months		1.000	
CCMP return, 6 months			1.000
Number of observations	253 312	253 312	253 312
Number of companies	2 225	2 225	2 225

Table A.6: Test of the proportional hazard assumption
This is the same test as the test conducted in table 5.1 except for the alternative Centrality measure used.

	(1)
Public Investor	1.003*
Firm Characteristics	
Sum of patents, last five years	1.000
Sum of alliances, last five years	0.995***
Location	0.999
Investor Characteristics	
Funding Rounds	0.999***
Accumulated amount invested	1.000
Firm age	1.000
Centrality Degree	1.000
Market Conditions	
S&P500 return, 3 months	1.000
Number of observations	253 312
Number of companies	2 225

3. Alternative robustness specifications

Table A.7: Exit through M&A – alternative event

Table 6.5 is constructed in the same way as table 5.4, except for the M&A event. In this regression we have redefined the second event to include exits such as acquisitions, pending acquisitions merger and LBO. The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit, the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Eigenvector centrality controls for the relative network positioning the risk capital investor has. S&P500 return, 3 months is a return index, capturing the market conditions for a given month. To strengthen the results section, all our regressions have been executed with robust standard errors.

	(1)	(2)	(3)	(4)
Public Investor	1.005	1.024	0.903	0.903
Firm Characteristics				
Sum of patents, last five years		1.006	0.987	0.987
Sum of alliances, last five years		1.332	1.464	1.462
Location		1.228**	1.071	1.070
Investor Characteristics				
Funding Rounds			1.239***	1.239***
Accumulated amount invested			1.001	1.001
Firm age			1.001*	1.001*
Centrality			1.005	1.005
Market Conditions				
S&P500 return, 3 months				1.001
Number of observations	260 175	260 175	253 351	253 312
Number of companies	2 227	2 227	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

Table A.8: Alternative S&P500 specifications

In this regression we investigate how alternative return specifications of the S&P500 index affect event study. The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit, the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Eigenvector centrality controls for the relative network positioning the risk capital investor has. S&P500 return, 1-month, S&P500 return, 3 months and S&P500 return, 6-months are all return index, capturing the market conditions for a given month. To strengthen the results section, all our regressions have been executed with robust standard errors.

	(1)	(1)	(1)
Public Investor	1.220**	1.221**	1.226**
Firm Characteristics			
Sum of patents, last five years	1.004	1.004	1.003
Sum of alliances, last five years	1.846***	1.844***	1.841***
Location	1.120*	1.120*	1.118*
Investor Characteristics			
Funding Rounds	1.309***	1.309***	1.308***
Accumulated amount invested	1.002***	1.002***	1.002***
Firm age	1.000*	1.000*	1.000*
Centrality	1.006*	1.006*	1.006*
Market Conditions			
S&P500 return, 1 month	1.018**		
S&P500 return, 3 months		1.014***	
S&P500 return, 6 months			1.019***
Number of observations	253 314	253 312	253 309
Number of companies	2 225	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

Table A.9: Alternative NASDAQ specifications

The 3-month S&P500 index return variable is replaced by the 1-, 3- and 6-month NASDAQ index return variables, capturing the market conditions. The data is studied on a monthly basis, where the dependent variable takes a value of zero before the exit. In the month of exit, the dependent variable equals one. Public investor is a dummy variable taking the value of 1 if the company is backed by VC and public investors, 0 otherwise. Sum of patents is defined as the accumulated patent applications submitted by a company over the last 5 years. Sum of alliances is constructed in a similar way. All alliances over the past 5 years are accumulated, again using a rolling window with the interval of one month. Location is a dummy variable differentiating companies based in California and Massachusetts from companies located elsewhere. Funding rounds measures the total number of financing rounds that has been taken place. Accumulated amount accounts for the total amount received until a given month. Firm age measures the average firm age of the risk capitalists that have invested in the company. Eigenvector centrality controls for the relative network positioning the risk capital investor has. To strengthen the results section, all our regressions have been executed with robust standard errors.

	(1)	(1)	(1)
Public Investor	1.218**	1.221**	1.057
Firm Characteristics			
Sum of patents, last five years	1.004	1.004	1.003
Sum of alliances, last five years	1.846***	1.844***	1.838***
Location	1.120*	1.119*	1.117
Investor Characteristics			
Funding Rounds	1.311***	1.311***	1.310***
Accumulated amount invested	1.002***	1.002***	1.002***
Firm age	1.000*	1.000*	1.000*
Centrality	1.006*	1.006*	1.006*
Market Conditions			
CCMP return, 1 month	1.007		
CCMP return, 3 months		1.009***	
CCMP return, 6 months			1.013***
Number of observations	252 269	252 251	252 224
Number of companies	2 225	2 225	2 225

*, **, and *** denote statistical significance at the 10, 5 and 1 percent level, respectively.

4. Log-rank Test

Table A.10: Log-rank test

Testing the null hypothesis that there is no difference in the probability of exit between companies that received private financing and those who received private and public financing. Since our P-value is 0, we can reject the null hypothesis on a 1-percent significance level, that private financing and public financing lead to the same probability of exit through IPO or M&A. The test is an alternative/complement to the Kaplan-Meier curve. Since covariates are not allowed in this test, we cannot control for company-level heterogeneity, so our inference from this test will be limited.

	Events observed	Events expected
Private	878	933.73
Public	170	114.27
Total	***1048***	***1048***
	chi2 (1) =	30.69
	Pr>chi2 =	0.0000

5. Alternative OLS specifications for IPO valuation

Table A.11: OLS-regressions with absolute price revision as the dependent variable

*The dependent variable pre-money is defined as the number of shares held by existing shareholders times the price in the initial public offering. Public investor is a dummy variable taking the value of 1 if the private company is backed by VC and public investors, otherwise 0. The average firm age variable measures the average number of years between the IPO date and the founding date of the risk capitalists. Geography is a dummy variable taking the value of 1 if the lead risk capitalist is located in the same state as the private company, 0 otherwise. Board dummy is a dummy variable taking the value of 1 if the lead public investor (in case of public investment) or the lead VC investor (in case the company is solely backed by venture capitalists) has at least one board position, 0 otherwise. SP5003, controls for the 3-month SP500 index return, accounting for the market condition. IPO condition reflects the number of conducted IPOs 3-months prior to the IPO date, and is later lagged with one quarter before entering the regression. Rank dummy is a dummy variable taking the value of 1if the lead underwriter has a ranking score of 8 or more, 0 otherwise. The centrality variable ensures that the quality of the investor is taken into account. We use the eigenvector centrality, which as stated before, incorporates the quality of connections between investors and not just the quantity. Company age is measured as the natural logarithm of unity plus the company age in years (IPO date – date of incorporation). Total funding is the total amount of investment received (in millions USD) prior to the IPO. Issue size is the expected amount to be received in the IPO (Number of shares issued*IPO price). Days424 is the logarithmic value of the number of days between the S-1/A filling and the 424 filling (log(424-S-1/A)).*

Absolute price revision	(1)	(2)	(3)	(4)	(5)
Public investor	-0.1762	-0.0311	-0.2952	-0.0332	-0.0305
Investor Charaterisics					
Average firm age		0.0016*	0.0015*	0.0014	0.0015
Geography		0.0081	0.0065	0.0058	0.0069
Board dummy		-0.1618	-0.0171	-0.0184	-0.0178
Market and IPO conditions					
SP5003	-0.0752	-0.7979		-0.0066	-0.0638
IPO condition			0.0022	0.0021	0.0022
Company and issue charateristics					
Rank dummy	0.0030	-0.0035	-0.0037	-0.0043	-0.0034
Centrality	-0.1831	-0.0321	-0.0397	-0.0345	-0.4088
Company age	0.0056	0.0052	0.0030	0.0023	0.0042
Total funding (million USD)	-0.0000	-0.0001	-0.0001		-0.0001
Issue size (million USD)	-0.0001	-0.0001	-0.0001		-0.0001
Days424	-0.0042	-0.0030	-0.0037	-0.0029	-0.0037
Constant	0.0071	0.0837	0.0744	0.0696	0.0752
Number of observations	217	215	215	215	215
R^2	0.0166	0.0310	0.0399	0.0319	0.0405
F-value	0.73	0.76	0.93	0.71	0.84
p-value	0.6660	0.6791	0.5149	0.7116	0.6055

Table A.12: OLS-regressions with Step-up multiple as the dependent variable
*The dependent variable pre-money is defined as the number of shares held by existing shareholders times the price in the initial public offering. Public investor is a dummy variable taking the value of 1 if the private company is backed by VC and public investors, otherwise 0. The average firm age variable measures the average number of years between the IPO date and the founding date of the risk capitalists. Geography is a dummy variable taking the value of 1 if the lead risk capitalist is located in the same state as the private company, 0 otherwise. Board dummy is a dummy variable taking the value of 1 if the lead public investor (in case of public investment) or the lead VC investor (in case the company is solely backed by venture capitalists) has at least one board position, 0 otherwise. SP5003, controls for the 3-month SP500 index return, accounting for the market condition. IPO condition reflects the number of conducted IPOs 3-months prior to the IPO date, and is later lagged with one quarter before entering the regression. Rank dummy is a dummy variable taking the value of 1if the lead underwriter has a ranking score of 8 or more, 0 otherwise. The centrality variable ensures that the quality of the investor is taken into account. We use the eigenvector centrality, which as stated before, incorporates the quality of connections between investors and not just the quantity. Company age is measured as the natural logarithm of unity plus the company age in years (IPO date – date of incorporation). Total funding is the total amount of investment received (in millions USD) prior to the IPO. Issue size is the expected amount to be received in the IPO (Number of shares issued*IPO price). DaysS1A is the logarithmic value of the number of days between the S-1 filling and the S-1/A filling (log(S-1/A-S-1)).*

Step-up multiple	(1)	(2)	(3)	(4)	(5)
Public investor	0.2657	0.4061	0.4427	0.4406	0.4103
Investor Charaterisics					
Average firm age		0.0066	0.0057	0.0057	0.0026
Geography		-0.3610	-0.3689	-0.3681	-0.4147
Board dummy		0.1354	0.1489	0.1477	0.1311
Market and IPO conditions					
SP5003	-0.7035	-0.4409		-0.1858	0.8910
IPO condition			0.0312*	0.0311	0.3123
Company and issue charateristics					
Rank dummy	-0.1232	-0.099	-0.9821	-0.0967	-0.1013
Centrality	-0.1186	-0.2218	-0.3325	-0.3355	-0.2895
Company age	-0.0153	0.0036	-0.2650	-0.0236	-0.0739
Total funding (million USD)	-0.0014**	-0.0013**	-0.0013**	-0.0013**	
DaysS1A	-0.1468	-0.1545	-0.1205	-0.1191	-0.1113
Constant	1.7087	1.6198	1.3219	1.3211	1.3370
Number of observations	199	197	197	197	197
R^2	0.0430	0.0605	0.0742	0.0743	0.0559
F-value	1.50	1.25	1.50	1.38	1.14
p-value	0.1679	0.2602	0.1427	0.1875	0.3345

Table A.13: OLS-regressions with Up-revision as the dependent variable
*The dependent variable pre-money is defined as the number of shares held by existing shareholders times the price in the initial public offering. Public investor is a dummy variable taking the value of 1 if the private company is backed by VC and public investors, otherwise 0. The average firm age variable measures the average number of years between the IPO date and the founding date of the risk capitalists. Geography is a dummy variable taking the value of 1 if the lead risk capitalist is located in the same state as the private company, 0 otherwise. Board dummy is a dummy variable taking the value of 1 if the lead public investor (in case of public investment) or the lead VC investor (in case the company is solely backed by venture capitalists) has at least one board position, 0 otherwise. SP5003, controls for the 3-month SP500 index return, accounting for the market condition. IPO condition reflects the number of conducted IPOs 3-months prior to the IPO date, and is later lagged with one quarter before entering the regression. Rank dummy is a dummy variable taking the value of 1if the lead underwriter has a ranking score of 8 or more, 0 otherwise. The centrality variable ensures that the quality of the investor is taken into account. We use the eigenvector centrality, which as stated before, incorporates the quality of connections between investors and not just the quantity. Company age is measured as the natural logarithm of unity plus the company age in years (IPO date – date of incorporation). Total funding is the total amount of investment received (in millions USD) prior to the IPO. Issue size is the expected amount to be received in the IPO (Number of shares issued*IPO price). Days424 is the logarithmic value of the number of days between the S-1/A filling and the 424 filling (log(424-S-1/A)).*

Up-revision	(1)	(2)	(3)	(4)	(5)
Public investor	0.0027	-0.0061	-0.0061	-0.0058	-0.0033
Investor Charaterisics					
Average firm age		0.0002	0.0001	0.0001	-0.0000
Geography		0.0039	0.0033	0.0031	-0.0011
Board dummy		-0.0092	-0.0104	-0.0101	-0.1130
Market and IPO conditions					
SP5003	0.0265	0.0152		0.0246	0.0128
IPO condition			0.0013**	0.0013**	0.0013**
Company and issue charateristics					
Rank dummy	0.0169***	0.0158**	0.0160**	0.0159**	0.0170**
Centrality	-0.0078	0.0004	-0.0052	-0.0047	-0.0104
Company age	-0.0075	-0.0071	-0.0072	-0.0077	-0.0091
Total funding (million USD)	-0.0000	-0.0000	-0.0000	-0.0000	
Issue size (million USD)	0.0001*	0.0002*	0.0002*	0.0002*	
Days424	-0.0012	-0.0008	-0.0010	-0.0011	-0.0025
Constant	0.0245	0.0240	0.0193	0.0190	0.0447
Number of observations	221	215	215	215	215
R^2	0.1206	0.1207	0.1368	0.1372	0.0655
F-value	3.20	2.20	2.69	2.47	1.63
p-value	0.0019	0.0158	0.0030	0.0050	0.1011

Table A.14: Overidentification test of instruments
Table A.14 displays the output from the test of the validity of the instruments used in the 2 stage least square regression (table 5.5, column 5). The instruments tested are "Average firm age", "Geography" and "Board dummy". The test reveals that our instruments are valid (the instruments are not correlated with the error term).

Overidentification test	
F-value	0.8146
p-value	0.6654

Table A.15: T-test pre-money

Investor	Observations	Mean	Standard error
Public investor	74	372.477	58.673
Venture capitalist	145	311.109	51.837
Combined	*219*	*331.845*	*39.606*
diff		***-61.368***	***83.823***
t-value	***-0.732***		

Table A.16: T-test absolute price revision

Investor	Observations	Mean	Standard error
Public investor	74	0.0856	0.012
Venture capitalist	144	0.107	0.010
Combined	*218*	*0.100*	*0.008*
diff		***0.021***	***0.016***
t-value	***1.341***		

Table A.17: T-test step-up multiple

Investor	Observations	Mean	Standard error
Public investor	69	1.093	0.171
Venture capitalist	131	0.836	0.102
Combined	*200*	*0.925*	*0.089*
diff		***-0.257***	***0.187***
t-value	***-1.372***		

Table A.18: T-test up-revision

Investor	Observations	Mean	Standard error
Public investor	74	0.034	0.007
Venture capitalist	152	0.026	0.004
Combined	*226*	*0.029*	*0.003*
diff		***-0.007***	***0.007***
t-value	***-1.068***		

Figure A.2: Filing process

S-1 filing	*S-1/A filing*	*424 filing (IPO)*
First step of the IPO-process	Mid-point of the IPO-process	Time of IPO
t = 0	t = 1	t = 2
Expected issue size	*Price range and number of shares*	*IPO-price and number of shares*