School of Business, Economics and Law
at University of Gothenburg

Master of Science in Finance

Venture capital and the hazard of exit: The role of corporate funds

Authors:
Joel Johansson
Tor Fardell

Supervisor:
Ph.D. Hans Jeppsson

A thesis presented for the degree of
Master of Science in Finance

Gothenburg, 2017

UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Graduate School

SCHOOL OF BUSINESS, ECONOMICS AND LAW AT UNIVERSITY OF GOTHENBURG

Abstract

Graduate School
Master of Science in Finance

Venture capital and the hazard of exit: The role of corporate funds

by Joel Johansson and Tor Fardell

We study how corporate venture capital investments affect the hazard of exit outcomes in start-up companies. The presence of corporate venture capital in a syndicate of venture capitalists raises the likelihood of exit. However, these exits are most likely to be IPOs. We find that corporate venture capital firms actively contribute to their portfolio companies, rather than simply invest in companies with higher quality or co-invest with other prominent venture capitalists. Our results indicate that conflicts of interest might arise in the presence of a strategic overlap between the parent firm of the corporate venture capitalist and the portfolio company. These results highlight the importance of the decisions a start-up has to make when choosing between alternative sources of financing.

Keywords: *Venture Capital, Corporate Venture Capital, Survival Analysis, Fine and Gray's Proportional Subhazard Model, Exit, IPO, M&A*

Acknowledgements

First and foremost, we want to express our profound appreciation to our supervisor, Ph.D. Hans Jeppsson, for the guidance and genuine devotion to this thesis. He has not only provided unconditional assistance in the overcoming of several obstacles, but also inspired us to stay motivated throughout the study.

We would also like to acknowledge Dr. Alexander Ljungqvist and Ph.D. Yang Lu for their acts of courtesy and valuable advice.

Without the contributions from these individuals, this thesis would not have been realized.

Contents

List of Figures

List of Tables

1. Introduction

In this paper, we shed light on the role that corporate venture capital (CVC) firms play in the exit route of a start-up company. We explore the impact of CVC on a start-up company's likelihood of going public or exit via M&A. In this manner, we seek to provide support to the critical financing decisions an entrepreneurial firm has to make when facing alternative sources of financing.

The documentation on the role of venture capital (VC) firms in start-up companies is vast and the literature is clear on the associations between venture capital and exit events. Nonetheless, most researchers disregard the significant dissimilarities amongst VC firms, resulting in approaches in which researchers often target independent venture capital (IVC) firms or simply consider all VC firms as independent actors. A disentanglement of this heterogeneous group, distinguishing CVC firms from IVC firms, proves fundamental differences between the two.

While these two types of funds have resembling missions and staff, there are intrinsic differences within the organizational and incentive structures. Corporate funds are predominantly set up as corporate subsidiaries, functioning as the venture arms of large corporations and have lower incentive-based compensation and autonomy than that of an independent fund (Gompers and Lerner 2000). With respect to these differences, implications on the ability to successfully nourish and exit start-up companies might be evident.

These idiosyncratic characteristics suggest that CVC firms could possibly let their portfolio companies enjoy beneficial features beyond those infused by IVC firms. The potentially close affiliation between a CVC firm and its often well-established industrial parent company provides an opportunity for the CVC firm to leverage the parent's resources in order to facilitate the growth and success of the portfolio company. This facilitation could include inside information about the industry, access to markets and distribution channels, R&D support or product development (Ivanov and Xie 2010). Additionally, receiving financing from a CVC firm can convey pivotal information to outside actors, which reduces uncertainty and thus brings credibility to the venture (McNally 1997).

However, the structural attributes connected to a CVC partnership might also impair the success of the venture. The low levels of autonomy and lack of robust incentive schemes might result in a departure of key personnel once they engage in relationships with outside investors (Gompers and Lerner 2000). Conversely, the high incentive-based compensation enjoyed in the limited partnerships set up in IVC funds, suggests that these venture capitalists will put high efforts into the management of the start-up. The structure of a CVC fund might also give rise to conflicts of interest, due to competing business lines between the corporate parent and the start-up (Hellmann 2002).

Consequently, disregarding these dissimilarities might develop integral implications to the pursuit of determining the impact of venture capital on a venture's outcome. Not only does a CVC firm differ dramatically from an IVC firm, but whether or not the advantages of CVC funding outweigh the potential disadvantages remains ambiguous. This ambiguity in conjunction with the heterogeneity amidst venture capitalists provide an eligible foundation for an empirical investigation regarding CVC firms' ability to successfully manage and exit entrepreneurial firms.

In the empirical application, we compare CVC-backed companies with IVC-backed companies by measuring the time-to-exit for 2,222 privately held firms in the biotechnology sector. Emanating from the founding of the firms, we develop a dataset with monthly records of start-up company characteristics, VC firm characteristics as well as prevailing market conditions in order to estimate the effect of CVC on the probability of an exit to occur. Specifically, we investigate if and to what extent the presence of CVC financing affects the likelihood that a firm goes public or exit through M&A. Consequently, it is sensible to analyze the impact of the degree to which CVC firms are involved in a venture. Not only to explore how the effect generated from the presence of CVC alters with different levels of involvement, but also to examine if CVC firms actively contributes to exit outcomes or simply invests in high-quality start-ups. We shed light on these possible features by utilizing two different measures of involvement level in order to ascertain whether or not the level of control exerted by CVC firms can affect the likelihood of an exit.

This thesis is related to a large body of literature covering the implications of venture capital in nascent companies. More explicitly, it is connected to studies on the organizational structure of VC firms and how VC financing relates to other types of financing alternatives. Ozmel, Robinson, and Stuart (2013) study the interplay between VC funding and strategic alliances, together with the impact these types of capital have on the probability that a start-up files for an IPO or becomes acquired. They find that increased VC funding raises the hazard of an IPO, as well as the hazard of an acquisition of the start-up firm.

Gompers and Lerner (2000) make use of the organizational and incentive structures in venture capital firms to examine the effect of the characteristical differences between CVC and IVC firms. They question whether the low incentive-based compensation in CVC firms can be offset by complementary advantages between the investment and the parent firm. To analyze this, they test if companies backed by IVC firms have a higher probability of going public or being acquired, than companies backed by CVC firms. They find that CVC investments appear to be at least as fruitful as IVC investments, particularly in the presence of a strategic overlap between the parent firm and the start-up.

Ivanov and Xie (2010) emphasize that it would be incomplete to examine the probability of success of CVC-backed companies without taking into account the company valuation at an IPO or acquisition. In contrast to Ozmel, Robinson, and Stuart (2013) and Gompers and Lerner (2000), they study the differences in IPO valuations and find that start-ups backed by CVC firms receives higher IPO valuations than start-ups backed by IVC firms. Ultimately, Ivanov and Xie (2010) conclude that CVC firms add more value to their portfolio companies than do IVC firms, since they not only exit a larger fraction of their portfolio companies, but also at a higher valuation.

This paper is also related to Hellmann (2002), who provides a model in which an entrepreneur chooses between independent and corporate venture capital, and where the optimal funding depends on synergies between the parent company and the start-up. Central to the model is the potential conflict of interest between CVC firms' search for strategic benefits and the economic success of the start-up. The predictions by Hellmann (2002) was tested by Masulis and Nahata (2009) and Santhanakrishnan (2002), whose results are consistent with the predictions of the model. Furthermore, Masulis and Nahata (2009) find a presence of large heterogeneity within the CVC investments, since 45% of the start-ups obtain funding from CVC firms with competitive technology.

The research by Gompers and Lerner (2000) is closely related to our study. However, we use a different methodology which, as opposed to Gompers and Lerner (2000), allows us reduce unobserved time-varying heterogeneity. In the research, a proxy for company quality is employed, defined as six different maturity stages. However, this proxy can be improved. One of their findings is that CVC firms usually invest at a higher valuation, which raises the question whether CVC firms simply invest in companies of higher quality. We want to extend their findings using a different proxy of time-varying firm quality. In contrast to Ozmel, Robinson, and Stuart (2013), who use alliances as outcome of interest, we use alliances as a sign of firm quality (Stuart, Hoang, and Hybels 1999). Overall, we gather inspiration from Ozmel, Robinson, and Stuart (2013), adopting a similar dataset and method. The main difference is our separation of venture capital into independent venture capital firms and corporate venture capital firms. Ivanov and Xie (2010) use a dataset of companies that ultimately files for an IPO. They find that start-ups backed by CVC firms are more successful than start-ups backed by IVC firms, in terms of IPO valuations. This interpretation is complete only if CVC-backed start-ups experience at least the same probability of IPO as IVC-backed start-ups do. Hopefully, we can contribute on this. We also seek to methodologically contribute to the literature by using a model that allows us to control for unobserved time-varying company-level heterogeneity among start-ups and VC firms.

1.1 Hypotheses development

The possible affiliation between a CVC firm and its corporate parent provides opportunities to increase the probability of successful investments. For example, they can provide their portfolio firms with technologies, R&D support, product development assistance, manufacturing capacities and access to marketing and distribution channels (Ivanov and Xie 2010; Chesbrough 2000). Whether or not these advantages outweigh potential disadvantages, such as relatively low incentive based compensation or conflict of interests between a CVC firm and a start-up, is a question subject for an empirical investigation.

- H1: Ceteris Paribus, a start-up company financed by corporate venture capital experiences a higher probability of exit than a start-up company financed by only independent venture capital.

Given that the first hypothesis is supported, our second hypothesis is built on the ambiguity that CVC firms either invest in companies of higher quality or that they actively manage their portfolio companies towards an exit. The financial contracts between a VC firm and an entrepreneur are incomplete, and the control, board and voting rights assigned in these contractare often central features of the partnership (S. N. Kaplan and Strömberg 2003). However, as Ivanov and Xie (2010) points out, CVC firms often co-invest with other VC firms, creating a syndicate of investors involved in the venture. The structure of the syndicate determines who control and manage the company, and should have an impact on the profitability and outcome of the start-up.

- H2: An increase in the degree to which a CVC is in control increases the probability of an exit for the start-up company.

2. Method

We use survival analysis to examine the covariates' effect on the probability that a start-up goes public or exit through M&A. For survival analyses, it is the time until an event occurs that constitutes the variable of interest. In our setting, time is defined as months since the founding date of the company and the event of interest is an IPO or M&A.

First, we employ a non-parametric approach in which we use the Kaplan-Meier estimator (E. L. Kaplan and Meier 1958) to obtain an initial but limited indication of the effect from CVC. In order to test the hypotheses and statistically assess the covariates' impact on the time-to-exit, we employ a semiparametric approach in which we use an extension of the Cox proportional hazards model (Cox 1972).

In Section 2.1 the non-parametric approach is laid out. Section 2.2 describes the semiparametric approach which takes time-varying covariates into account. The proportional hazards assumption is explained in Section 2.3 and in Section 2.4 we describe the model, central to this thesis, which accounts for competing risks.

2.1 The Kaplan-Meier estimator

The Kaplan-Meier estimator (E. L. Kaplan and Meier 1958) is a non-parametric approach to estimate survival functions, in the sense that it makes no assumptions about the functional form of the survival function or hazard. The survival function can be stratified by several groups and the difference between them can be tested. However, the survival functions are not modified by the covariates.

The estimator is given by

$$\widehat{S}(t) = \prod_{j|t_j \leq t} \left(\frac{n_j - d_j}{n_j} \right), \tag{2.1}$$

where n_j is the number of individuals at risk at time t_j and d_j is the number of failures at time t_j. The function is a running product of the conditional probabilities at time t_j, given that the event occurred before time t. Intuitively, the data is ordered by time and the Kaplan-Meier estimator empirically determines the number of failures at each time to estimate the survival function.

2.2 The Cox proportional hazards model

If we let T be a nonnegative random variable representing the time to an event, the cumulative distribution function of T is defined as $F(t) = \Pr(T \leq t)$ and the survivorship function is

$$S(t) = 1 - F(t) = \Pr(T > t), \tag{2.2}$$

which yields the probability that the event has not occurred before t. This function is equal to one at $t = 0$ and zero as $t \to \infty$.

For $f(t)$, the probability density function of T, the hazard function is given by

$$h(t) = \lim_{dt \to 0} \frac{\Pr(t \leq T < t + dt | T \geq t)}{dt} = \frac{f(t)}{S(t)}. \tag{2.3}$$

The hazard function in equation (2.3) is the probability that the event occurs in a small interval, i.e. the instantaneous probability, given that the subject has survived up until then. The function can take values from zero to infinity and change shape over time. The accumulated amount of risk for a subject up until a certain point is given by the cumulative hazard function

$$H(t) = \int_0^t \frac{f(u)}{S(u)} du = -\int_0^t \frac{1}{S(u)} \left(\frac{d}{du} S(u) \right) du = -\ln S(t). \tag{2.4}$$

From (2.4) it is clear that if you have one of the four functions that describe the distribution of T, you can solve for the other three.

The hazard function for subject j, estimated by the Cox proportional hazards model Cox (1972) is given by

$$h(t|\mathbf{x}_j) = h_0(t)\exp(\mathbf{x}_j \boldsymbol{\beta}_{\mathbf{x}}). \tag{2.5}$$

Hence, the hazard that subject j faces is some function h_0 which each subject faces, adjusted for the covariates $\mathbf{x}_j$. Because of the form of the model, the estimated hazards are always nonnegative. The hazard ratio is defined as the hazard for one subject divided by the hazard for a different subject. For covariates $\mathbf{x}_j$ and $\mathbf{x}_m$, the hazard ratio is

$$\widehat{\text{HR}} = \frac{\hat{h}(t, \mathbf{x}_j)}{\hat{h}(t, \mathbf{x}_m)} = \frac{\hat{h}_0(t)\exp(\mathbf{x}_j \boldsymbol{\beta}_{\mathbf{x}})}{\hat{h}_0(t)\exp(\mathbf{x}_m \boldsymbol{\beta}_{\mathbf{x}})}. \tag{2.6}$$

Since the baseline function cancels out, the model becomes a semiparametric model. Hence, we do not need to make any assumption about the baseline specification in order to estimate the coefficients. The model lose some efficiency because of this, but becomes more general, allowing for any type of baseline function.

2.3 The Proportional Hazards Assumption

While the Cox proportional hazards model Cox (1972) makes no assumption about the baseline hazard, it assumes that the relative hazard is invariant over time. That is, the hazard ratios has to be constant, as indicated by the coefficients in (2.5) and (2.6), which are independent of time. This is called the proportional hazards assumption, stating that the effect of a covariate should not vary with time. Written differently, if you plot the hazard rates of two groups in order to determine if one of the groups survives longer than the other, the hazards rates should be parallel over time for the assumption to hold. If the assumption is violated, it is not possible to assign one hazard ratio for all time periods.

Assessing the assumption from a plot is highly subjective. Instead, we evaluate the proportional hazards assumption by including covariates interacted with time, and test the hypothesis that the coefficients on the interacted variables are equal to zero. If the assumption holds, the effect of these interacted variables should not be different from zero.

2.4 The Fine and Gray model for competing risks

The dataset contains information about the final outcome of each company. The start-ups eventually files for an IPO, becomes acquired, goes bankrupt or drops out of the dataset due to some other reason. Since we are interested in the time until only one of these events occurs the other outcomes are what is called competing risks. As a direct analog to Cox regressions, we employ the model developed by Fine and Gray (1999) which incorporates the concept of competing risks.

To grasp the concept of competing risks, it is essential to understand censoring. In survival analysis, a subject is tracked over time until the event of interest occurs or until the follow-up ends. Despite the fact that some subjects never experience the event and remain in the dataset at the end of the follow-up, the absence of an event still conveys applicative information. An implicit assumption is that if the study was to be prolonged, each subject would eventually experience the event. Instead, the duration between the end of the follow-up and the occurrence of the event of the subject is censored. In other words, the event will ultimately occur, but the time of the event is imperceptible. The concept of censoring also applies for subjects that fall out of the dataset prior to the end of the follow-up.

If the cause of a censored subject is random and uncorrelated with the event of interest, the estimations will not be subject to bias. However, if a subject is excluded from the dataset due to an event that precludes the event of interest from occurring, the estimates could be biased. For example, a company experiencing bankruptcy should not be subject for censoring since an IPO at the time after the occurrence of the bankruptcy is inaccessible. Instead, through utilization of the model by Fine and Gray (1999), events that precludes the primary event of interest from occurring, are treated as competing risks. Competing risks can also be present in studies in which the analyst wishes to examine the event that occurs first in a set of multiple consecutive events.

The model by Fine and Gray (1999), which is an extension of the Cox proportional hazards model Cox (1972), accounts for competing risks by keeping subjects at risk of experiencing the event of interest even after they experienced a competing event. However, without being able to experience the event of interest.

The subhazard function for cause i is defined as

$$h_i(t) = \lim_{dt \to 0} \frac{\Pr(t \leq T < t + dt, \varepsilon = i | T \geq t \cup (T \leq t \cap \varepsilon \neq i)}{dt}. \tag{2.7}$$

The model of the subhazard for cause i is

$$\bar{h}_i(t|\mathbf{x}_j) = h_{i,0}(t)\exp(\mathbf{x}_j\boldsymbol{\beta}). \tag{2.8}$$

As in a Cox regression, the model is semiparametric and the covariates are assumed to be proportional.

3. Data

This section encompasses a description of the data we employ in the models. Section 3.1 describes our sample, selection process, data sources and summary statistics. Section 3.2 delineates the covariates we include in the models.

3.1 The sample

The sample consists of records on 2,222 venture capital-backed private biotechnology companies domiciled in the U.S., assembled from Thomson Financial's VentureXpert database. The sample selection is presented in Table 3.1. Because all companies in the sample received at least one round of venture capital financing, the sample is not random. This sampling method enables us to reduce some firm quality heterogeneity. By sampling companies conditioned on venture capital financing, we eliminate the lowest quality companies deficient of attracting venture capital. Moreover, by examining start-ups in the biotechnology sector we facilitate the otherwise ambiguous task of measuring time-varying firm quality. It enables us to utilize patents as a convenient firm quality proxy. Nonetheless, since we limit our sample to U.S. biotechnology start-ups, we are cautious about attaching any general interpretations about venture capital markets to our findings. The data includes the identities, the founding dates, the dates of exits and the type of these exits for the companies. The data also comprise transaction data on 231 M&A deals. We also use the VentureXpert database to assemble the VC investments corresponding to the companies. This data consists of dates of the investment rounds, identities of the VC firms and the equity amount invested by these. In rare cases, the first investment occur prior to the founding date according to the dataset. We address this by an adjustment so that the founding date for the company in question coincides with the date of the first investment. This is motivated by the fact that a non-negligible number of firms in the unadjusted sample are founded at or close after the date of the initial investment.

We make use of the Deloitte Recap (formerly Recombinant Capital) database to augment the VentureXpert data. This allows us to preclude misleading information of the exit events by identifying if the event of interest actually occurred before that of the original data or if the event type is incorrectly specified.

The companies undergo two events of interest; they either go public or they exit through M&A. The residual companies either experience bankruptcy, discontinuation or remain active at the end of the follow-up. VentureXpert is occasionally sparse in the information on the dates of discontinuation. For these particular companies,

Table 3.1: Sample selection

Sample selection criteria	Sample size
Venture capital deals (1965-2017)	13,837
Excluding	
Non-US firms	(5,806)
Medical/Health/Life Science firms	(4,950)
Firms without financing from either CVC or IVC	(313)
Duplicates	(546)
Total	2,222

we assign the last investment date to the date of discontinuation as an indication of the most recent sign of activity. The total number of the events of interest grouped by VC firm type, along with the event frequency sorted by year of founding are presented in Table 3.2. As indicated by the bottom line, of the 968 companies financed by CVC firms, 285 went public and 196 underwent M&A. For the 1,254 companies financed by IVC firms, 215 went public and 301 underwent M&A. Both IPOs and M&As are concentrated among the companies founded in the 1990s.

Table 3.2: This table presents time-series data of the 2,222 firms in the sample. The first column lists the years of founding for the firms. The second column lists the number of firms founded each year. Column 3-7 includes statistics on firms that received at least one financing round from a CVC firm. Column 8-12 includes statistics on firms that only received financing from IVC firms. Within these two cohorts are the number of firms founded, the number of firms that later went public, the number of firms that later exit through M&A, the average number of patents and the average number of alliances for the firms founded in the year given by Column 1.

		Financed by CVC					Financed by IVC				
Year	Firms founded	No. of firms	IPOs	M&As	Avg. no. of patents	Avg. no. of alliances	No. of firms	IPOs	M&As	Avg. no. of patents	Avg. no. of alliances
<1980	49	17	8	4	4	0.4	32	15	5	2	0.2
1980	22	10	6	4	4	1.2	12	4	5	1	0.1
1981	40	25	17	2	19	0.6	15	3	7	6	0.5
1982	23	12	4	5	12	1.3	11	6	1	8	1.0
1983	32	12	8	2	4	0.7	20	10	4	8	1.0
1984	16	7	3	1	16	3.0	9	4	3	5	0.2
1985	30	14	5	4	4	0.5	16	2	4	6	0.4
1986	28	13	7	4	7	4.1	15	7	2	9	0.8
1987	50	13	5	7	12	1.3	37	17	8	6	0.7
1988	41	8	6	1	13	0.5	33	9	15	5	0.4
1989	30	8	3	4	9	1.1	22	6	9	6	0.6
1990	27	4	2	2	23	0.3	23	10	6	6	0.4
1991	24	6	3	8	10	0	18	9	4	16	0.8
1992	57	25	11	9	16	0.8	32	7	17	13	0.4
1993	55	25	11	6	15	0.6	30	6	10	5	0.4
1994	48	17	7	3	29	1.8	31	7	10	6	0.2
1995	56	28	16	7	21	0.6	28	4	12	3	0
1996	65	19	8	9	17	0.6	46	7	22	6	0.3
1997	76	37	14	7	16	1.2	39	4	17	7	0
1998	79	35	12	8	17	0.4	44	7	14	9	0.3
1999	64	31	12	17	15	0.3	33	7	13	6	0
2000	99	55	13	13	9	0.6	44	5	10	6	0.1
2001	82	34	5	9	18	0.2	48	7	14	4	0.1
2002	65	35	12	16	10	0.3	30	4	9	6	0.1
2003	84	42	8	6	8	0.2	42	5	13	2	0
2004	76	32	11	9	9	0.3	44	8	5	5	0
2005	99	46	8	12	5	0.1	53	5	6	4	0
2006	100	50	10	7	6	0.1	50	6	12	4	0
2007	104	51	10	6	5	0.2	53	4	9	4	0
2008	104	46	10	3	5	0.1	58	3	9	2	0
2009	73	29	4	1	3	0.1	44	4	4	2	0
2010	60	25	7	0	3	0	35	3	3	1	0
2011	91	30	5	0	2	0	61	5	7	1	0
2012	66	34	5	0	1	0	32	1	4	0	0
2013	71	35	5	1	1	0	36	3	5	0	0
2014	52	26	4	0	0	-	26	1	1	0	-
2015	54	25	0	0	0	-	29	0	2	0	-
2016	30	7	0	0	0	-	23	0	0	0	-
Total	2,222	968	285	196	9	0.6	1,254	215	301	4	0.2

We manually collected patent application dates for each company from the United States Patent and Trademark Office (USPTO) patent database. The most recent company names as well as the company aliases were used to match the patents. As indicated by Table 3.2, the total average number of patents in companies financed by CVC firms exceeds the total average number of patents in companies financed by IVC firms by almost the double.

We use the Recap database to collect alliance data for all companies. The dataset consists of data on over 10,000 alliances in the biopharmaceutical sector between 1978-2013, including transaction dates and underlying contract information. In Table 3.2, the total average number of alliances indicates a higher presence of alliances in the start-ups backed by CVC firms, than those backed by IVC firms.

We finally collect primary industry classifications using SIC codes for all CVC firms' parent companies extracted from Dow Jones Factiva.

3.2 Independent variables

The independent variables are categorized into company characteristics, VC characteristics and market conditions. For each start-up company, these variables are collected on a monthly basis starting from the date of founding.

3.2.1 Company characteristics

It is possible that relationships between VC funding and exit events are affected by omitted variables. If an unobserved firm quality variable increases the hazard of going public and at the same time increases the ability to raise venture capital, the ability to raise capital might ambiguously imply firm quality. The differences between CVC-backed and IVC-backed firms in both patents and alliances outlined by Table 3.2, provides additional gravity of this potential issue. By including two different time-varying firm quality variables we are able to reduce unobserved, time-varying, company-level heterogeneity. However, without the presence of instrumental variables, we must be deliberate in imputing causalities to our estimations.

Emanating from the findings of Hsu and Ziedonis (2008), we include stock of patents as a first measure of firm quality. More specifically, we accumulate the number of patent applications during the past five years, by registering the date of patent applications (Sørensen and Stuart 2000; Ozmel, Robinson, and Stuart 2013).

The second measure we include is the number of strategic alliances during the past five years. A young biotechnology company entering an inter-organizational relationship, such as an alliance, functions as firm quality signaling to the public as it reduces uncertainty about the venture (Stuart, Hoang, and Hybels 1999).

As argued by Lerner (1995), geographical proximity of VC firms is an important determinant of access to venture capital. Following Gompers and Lerner (2000) and Ivanov and Xie (2010), we incorporate a dummy variable indicating whether the companies are based in either California or Massachusetts in order to capture the possible geographical effect.

Following Gompers and Lerner (2000) and Ivanov and Xie (2010), we include a measure of strategic fit between the start-ups and the CVC firms' parent companies. First, we assign the start-ups with each 3-digit SIC code corresponding to the biotechnology sector. These codes, along with their definitions, are accessible in Appendix A.2. If at least one parent company SIC code corresponds to any of the assigned SIC codes, a strategic fit is considered to be present. The measure is incorporated as a dummy variable, denoting the presence or absence of a strategic fit.

3.2.2 VC characteristics

First, we incorporate a measure of whether a company is financed by a CVC firm. A company is defined to be financed by a CVC firm in the month of the first investment attributable to a CVC firm and in all subsequent months. This measure is then amplified to define whether a company is CVC-backed with or without the presence of a strategic fit.

Second, we measure the degree to which CVC firms are involved in a venture. Methodologically, this measure acts as a proxy for the level of control exerted by CVC firms. Since the VentureXpert database does not disclose individual stakes held by each investor, the measure is solely defined as the accumulated amount of equity invested by CVC firms as a share of the total amount invested by all investors. For robustness purposes, we employ an alternative measure defined as the number of CVC investments in relation to the total number of investments.

For each company i in month t, we incorporate the accumulated number of funding rounds obtained by the company. In the same manner, we also include the accumulated equity amount invested, measured in millions of dollars.

We also include a variable that measures the influence of each VC firm, as a measure of VC firm quality. More influential VC firms have access to a more extensive range of expertise and capital, and are associated with a higher probability of experiencing a successful exit either through an IPO or an acquisition (Hochberg, Ljungqvist, and Lu 2007). In accordance with Hochberg, Ljungqvist, and Lu (2007), we measure the influence using eigenvector centrality developed by Bonacich (1972) defined as:

$$c_{i,t} = \frac{1}{\lambda} \sum_{j=1}^{N_t} A_{i,j,t} c_{j,t} \tag{3.1}$$

or in matrix notation,

$$\boldsymbol{cA} = \lambda \boldsymbol{c}, \tag{3.2}$$

where $c_{j,t}$ denotes the centrality of firm j in month t and $A_{i,j,t}$ is the binary adjacency matrix indicating the presence of a co-investment between firm i and firm j between t and $t-5$. N_t denotes the sum of active VC firms in the time interval $[t-5, t]$ and λ is a normalizing parameter defined as the theoretical maximum eigenvector centrality in a network of n actors. A numerical example accessible in

Appendix A.3 presents a more detailed construction of the centrality measure. In essence, the eigenvector centrality is a recursive measure that weights a VC firm's connections to other VC firms, defined as co-investments, by the centrality of the VC firms corresponding to these connections. Since the companies are usually financed by syndicates of venture capitalists, the assigned centrality is calculated as a mean of the centralities of the VC firms at month t.

For each company i in month t, we register the average number of months since the investing VC firms were founded, similar to (Gompers and Lerner 2000). We call this measure "VC firm age, average".

3.2.3 Market conditions

According to Lerner (1994) and Ball, Chiu, and Smith (2011), IPO activity tends to be positively correlated with high equity valuations. Similarly, the stock market conditions are also likely to be of integral importance to M&A activity as it reflects the general economic conditions. In order to control for the equity market conditions, we include the Standard & Poor's 500 (S&P500) 3-month index return. For robustness purposes, we also replace the S&P500 3-month index return with unreported alternative measures. These include S&P500 index return on 1-month and 6-month basis, as well as NASDAQ Composite Index (CCMP) return on 1-, 3- and 6-month basis.

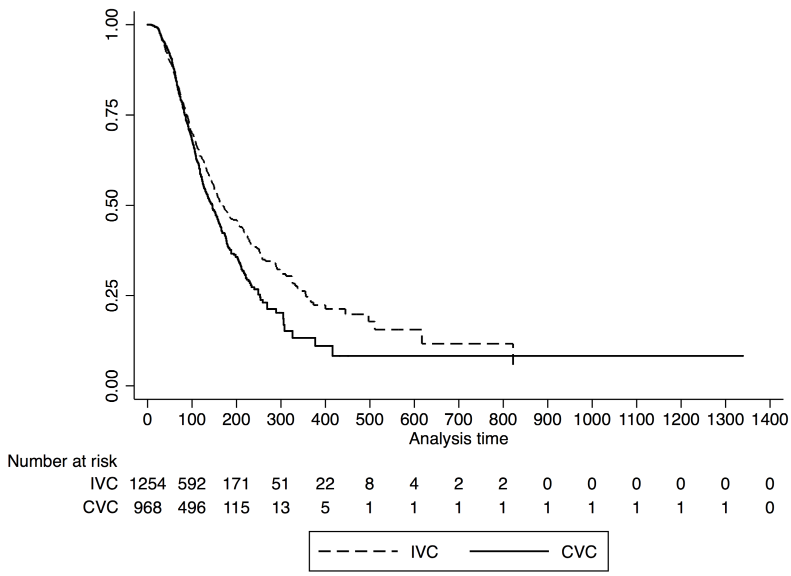
4. Results

This section presents the results with which we explore the role of CVC in different exit routes. We employ survival analyses with two different approaches and the sections are distributed accordingly. Section 4.1 is dedicated to a non-parametric approach and Section 4.2 presents a semiparametric approach.

4.1 A non-parametric approach

We begin by estimating the survival functions for two groups, using the Kaplan-Meier estimator; companies financed by at least one CVC firm and companies financed by IVC firms only. A company experiencing an event is defined as exiting either through an IPO or M&A. Figure 4.1 plots the survivor curves obtained from the Kaplan-Meier estimation. The separation of the curves indicates that CVC-backed companies are more likely to exit than IVC-backed companies. A log-rank test for equality of survivor functions is rejected at the 1 percent significance level. The test is accessible in Appendix A.4. Since the Kaplan-Meier estimator is restricted by the absence of covariates, we are unable to control for company-level heterogeneity. Hence, the interpretations are restricted as well.

Figure 4.1: Kaplan-Meier survival estimates.
An event is defined as exiting through either an IPO or M&A. The analysis time is measured in months. The number of companies at risk, separated by the type of VC firm, are displayed below the graph.



4.2 A semiparametric analysis of exit options

We now estimate the hazard of different exit options as a function of company characteristics, VC characteristics and market conditions. This is performed using the model by Fine and Gray (1999) which accounts for competing events. That is, events that impedes the event of interest to occur. The variables that are significant in the proportional hazards assumption test are included as control variables but are unreported. First, we estimate the degree to which the presence of CVC investments affect the probability of exits. Next, we amplify these estimates by including the level of involvement, contingent on the presence of CVC.

4.2.1 The presence of CVC involvement

Column 4 in Table 4.1 presents subhazard estimates of exit through IPO or M&A, controlling for company characteristics, VC characteristics and market conditions. The competing events are defined as bankruptcy and discontinuation. A company backed by CVC has a 25.3% higher probability of exit than a company backed by IVC. This is significant at the 1 percent level. An additional patent application filed over the last five years increases the hazard by 1,1%. This is economically significant, considering the average number of patents across all companies, which translates to a 7% increase in the hazard. This effect is in line with Hsu and Ziedonis (2008). An alliance partnership raises the hazard of exit by 49%, significant at the 1 percent level. Consistent with Ozmel, Robinson, and Stuart (2013), a company with more financing rounds has an increased probability of experiencing an exit. This is also true for the amount invested by the VC firms. As the hazard ratio corresponds to a 1 million dollar increase in the total amount invested, the average amount invested corresponds to a 11.4% increase of the hazard, emphasizing the economic significance. Higher VC centrality has a positive impact on the hazard of exit, consistent with the findings of Hochberg, Ljungqvist, and Lu (2007). The effect of VC firm age is positively significant as well. Finally, the 3-month S&P500 index return has a positive impact on the probability of exit. This result is robust for different time frames and the CCMP index returns.

The results from Column 4 in Table 4.1 supports the hypothesis that a CVC-backed company experiences a higher hazard of exit than does an IVC-backed company. When company and VC characteristics are added to the regression, the hazard ratio of a CVC investment drops from 2.184 to 1.249. This suggests that the increased hazard of exit in Column 4 is not driven by investments in high firm-quality companies nor that the CVC firms are more experienced and reputable compared to the IVC firms. That is, CVC firms do not only co-invest with other prominent IVC firms or pick superior portfolio companies. Instead, they are able to add value to a start-up that is incremental to the value added services from IVC firms.

Column 5 in Table 4.1 reports the subhazard estimates for CVC-backed companies categorized with or without strategic fit. Interestingly, the presence strategic fit have no significant impact on the hazard of exit, while the absence of strategic fit increases the hazard at the 1 percent significance level. This is inconsistent with the results in Gompers and Lerner (2000) and Ivanov and Xie (2010). However, this can possibly be explained by the fact that Gompers and Lerner (2000) examine each parent firm's annual report to identify matching business lines and Ivanov and Xie (2010) search IPO prospects for mentions about strategic relations, while we use SIC codes to determine the presence of a strategic fit. The SIC code approach manages to capture matching industry sectors and possible complementary effects, but it might also capture relations between a corporate parent and a start-up in which competitive disadvantages exist. This suggests that the ventures assigned with strategic fit are heterogeneous, supported by the findings of Masulis and Nahata (2009). The model by Hellmann (2002) suggests that a CVC investment can either benefit or turn into a disadvantage for start-ups depending on whether or not the objectives of the CVC are aligned with the objectives of the start-up. Hence, if a start-up and a CVC parent share the same SIC code, there might be offsetting effects, reflected by the insignificant hazard ratio. However, if the SIC codes mismatch, the probability of competing products could be lower, as suggested by our results. The remaining variables share the same significance level and interpretation as in Column 4.

Table 4.1: Subhazard estimates of exit through IPO or M&A.
This table presents subhazard estimates of an exit (IPO or M&A). The competing events are defined as bankruptcy and discontinuation. An observation consists of a given company in a given month. The dependent variable equals zero before the case of a potential exit and equals one in the month of the exit. "CVC investment" is a dummy variable taking on the value one in the month of an equity investment from a CVC firm and in all subsequent months. "CVC investment with strategic fit" is a dummy variable taking on the value one if the investing CVC firm has a strategic fit. "CVC investment without strategic fit" is a dummy variable taking on the value one if the investing CVC firm does not have a strategic fit. "Sum of patents, last five years" is the number of patent applications filed by a company over the last five years. "Sum of alliances, last five years" is the number of strategic alliances a company has experienced over the last five years. "Based in California or Massachusetts" is a dummy variable taking on the value one if a company is based in California or Massachusetts and zero otherwise. "Sum of VC rounds" measures the accumulated number of funding rounds received by a company in each month. "Accumulated amount invested" is the total equity amount invested in each month, measured in millions of dollars. "VC centrality, average" measures the average influence of all VC firms that have invested in a company at each month. "VC firm age, average" measures the average number of months since the founding of the VC firms that have invested in a company in each month. "S&P500 return, 3m" is the Standard & Poor's 500 3-month index return. The subhazard analysis is executed with robust standard errors.

	(1)	(2)	(3)	(4)	(5)
CVC investment	2.184***	1.986***	1.249***	1.253***	
CVC investment with strategic fit					1.063
CVC investment without strategic fit					1.379***
Company characteristics					
Sum of patents, last five years		1.016***	1.011***	1.011***	1.011***
Sum of alliances, last five years		1.326**	1.487***	1.490***	1.518***
Based in California or Massachusetts		1.341***	0.970	0.971	0.958
VC characteristics					
Sum of VC rounds			1.149***	1.151***	1.153***
Accumulated amount invested			1.003***	1.003***	1.003***
VC centrality, average			1.040***	1.039***	1.042***
VC firm age, average			1.001***	1.001***	1.001***
Market conditions					
S&P500 return, 3m				1.016***	1.015***
Number of observations	254,729	254,729	240,231	239,879	234,549
Number of companies	2,222	2,222	2,191	2,191	2,187

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

Defining exit as both IPO and M&A might be subject to some heterogeneity. Mainly due to the fact that IPO generally is a more profitable exit alternative (Brau, Francis, and Kohers 2003; Bienz and Leite 2008; Gompers and Lerner 1997). To address this, we conduct two separate regressions with IPO and M&A as the outcome of interest.

Table 4.2 reports subhazard estimates of exit through IPO, treating M&A, bankruptcy and discontinuation as competing events. The hazard ratio of "CVC investment" is significant at the 1 percent level and highly economically significant. A start-up that receives funding from a CVC firm has a 61.8% higher likelihood of going public, than companies with no CVC-funding. As with the hazard of exit, the patent variable continues to have a positive effect at a high significance level. An additional alliance partnership significantly increases the probability of IPO by 64.2%. This effect is consistent with Ozmel, Robinson, and Stuart (2013). The location of the start-up

Table 4.2: Subhazard estimates of exit through IPO.
This table presents subhazard estimates of exit through IPO. The competing events are defined as M&A, bankruptcy and discontinuation. An observation consists of a given company in a given month. The dependent variable equals zero before the case of a potential exit and equals one in the month of the exit. "CVC investment" is a dummy variable taking on the value one in the month of an equity investment from a CVC firm and in all subsequent months. "CVC investment with strategic fit" is a dummy variable taking on the value one if the investing CVC firm has a strategic fit. "CVC investment without strategic fit" is a dummy variable taking on the value one if the investing CVC firm does not have a strategic fit. "Sum of patents, last five years" is the number of patent applications filed by a company over the last five years. "Sum of alliances, last five years" is the number of strategic alliances a company has experienced over the last five years. "Based in California or Massachusetts" is a dummy variable taking on the value one if a company is based in California or Massachusetts and zero otherwise. "Sum of VC rounds" measures the accumulated number of funding rounds received by a company in each month. "Accumulated amount invested" is the total equity amount invested in each month, measured in millions of dollars. "VC centrality, average" measures the average influence of all VC firms that have invested in a company at each month. "VC firm age, average" measures the average number of months since the founding of the VC firms that have invested in a company in each month. "S&P500 return, 3m" is the Standard & Poor's 500 3-month index return. The subhazard analysis is executed with robust standard errors.

	(1)	(2)	(3)	(4)	(5)
CVC investment	3.100***	2.710***	1.613***	1.618***	
CVC investment with strategic fit					1.355**
CVC investment without strategic fit					1.732***
Company characteristics					
Sum of patents, last five years		1.021***	1.017***	1.017***	1.017***
Sum of alliances, last five years		1.400**	1.618***	1.642***	1.650***
Based in California or Massachusetts		1.362***	0.918	0.915	0.936
VC characteristics					
Sum of VC rounds			1.107***	1.107***	1.112**
Accumulated amount invested			1.004***	1.004***	1.004***
VC centrality, average			1.041***	1.039**	1.040**
VC firm age, average			1.000	1.000	1.001
Market conditions					
S&P500 return, 3m				1.033***	1.033***
Number of observations	254,729	254,729	240,231	239,879	234,549
Number of companies	2,222	2,222	2,191	2,191	2,187

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

has no impact of the hazard of going public. Companies with a higher number of VC rounds and accumulated amount invested are more likely to exit through an IPO. VC centrality is positively significant at the 5 percent level, while the age of VC firms is insignificant. The market conditions play an important role in the going public decision. This is in line with Lerner (1994) and Ball, Chiu, and Smith (2011), who finds that companies tend to go public when equity valuations are high.

As with the hazard of exit, the point estimate for a CVC investment without strategic fit is above 1 and highly significant. Interestingly, the estimate for a CVC investment with strategic fit, however, is now significant at the 5 percent level, indicating a positive impact on the hazard of going public. Whether or not a strategic fit is present, a CVC investment will increase the probability of an IPO. Yet, the point estimate is higher for investments without strategic fit. For Column 5, the remaining variables remain fairly unchanged with regards to both hazard ratios and significance levels.

Table 4.3 analyzes the hazard of exit through M&A, treating IPO, bankruptcy and discontinuation as competing events. CVC-financing has no significant impact on the hazard of M&A. This provides two possible interpretations. First, we find that M&A is not necessarily a successful outcome. Among the parsimonious transaction

Table 4.3: Subhazard estimates of exit through M&A.
This table presents subhazard estimates of exit through M&A. The competing events are defined as IPO, bankruptcy and discontinuation. An observation consists of a given company in a given month. The dependent variable equals zero before the case of a potential exit and equals one in the month of the exit. "CVC investment" is a dummy variable taking on the value one in the month of an equity investment from a CVC firm and in all subsequent months. "CVC investment with strategic fit" is a dummy variable taking on the value one if the investing CVC firm has a strategic fit. "CVC investment without strategic fit" is a dummy variable taking on the value one if the investing CVC firm does not have a strategic fit. "Sum of patents, last five years" is the number of patent applications filed by a company over the last five years. "Sum of alliances, last five years" is the number of strategic alliances a company has experienced over the last five years. "Based in California or Massachusetts" is a dummy variable taking on the value one if a company is based in California or Massachusetts and zero otherwise. "Sum of VC rounds" measures the accumulated number of funding rounds received by a company in each month. "Accumulated amount invested" is the total equity amount invested in each month, measured in millions of dollars. "VC centrality, average" measures the average influence of all VC firms that have invested in a company at each month. "VC firm age, average" measures the average number of months since the founding of the VC firms that have invested in a company in each month. "S&P500 return, 3m" is the Standard & Poor's 500 3-month index return. The subhazard analysis is executed with robust standard errors.

	(1)	(2)	(3)	(4)	(5)
CVC investment	1.198*	1.218**	0.937	0.937	
CVC investment with strategic fit					0.845
CVC investment without strategic fit					1.029
Company characteristics					
Sum of patents, last five years		0.996	0.997	0.997	0.997
Sum of alliances, last five years		0.843	0.846	0.847	0.816
Based in California or Massachusetts		1.167**	1.053	1.055	1.022
VC characteristics					
Sum of VC rounds			1.029	1.029	1.030
Accumulated amount invested			0.996**	0.996**	0.996**
VC centrality, average			1.018*	1.018*	1.023**
VC firm age, average			1.002***	1.002***	1.002***
Market conditions					
S&P500 return, 3m				0.996	0.996
Number of observations	254,729	254,729	240,231	239,879	234,549
Number of companies	2,222	2,222	2,191	2,191	2,187

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

data, we observe that a fraction of the transactions are very small in relation to the total funding, which might imply unsuccessful exits for the investors. Therefore, the noisiness in the data makes it difficult to explain the hazard of exit through M&A. This inconvenience might also be reflected in the other insignificant variables. Second, a collective evaluation of the results in Table 4.1, 4.2 and 4.3, indicates that CVC firms tend to exit through IPO rather than M&A, as demonstrated by the increased hazard of an exit which is mainly driven by the increased hazard of going public. When a company is backed by CVC, the hazard of IPO increases but leaves the hazard of M&A unaffected. Combining these two outcomes as visible in Table 4.1, a CVC investment still increases the likelihood of an exit. This might be explained by the unique organizational structure in corporate venture programs. The prespecified finite life of limited partnerships set up in IVC firms is to a large extent missing in CVC firms (Cumming 2010). In this respect, CVC firms might have more leeway to bring portfolio companies public when equity valuations are high. However, since a venture is typically set up as a syndicate of both IVC firms and CVC firms, the leeway is dependent on the level of control exerted by the CVC firms involved. Furthermore, because the presence of CVC mainly raises the hazard of IPO, it might be that CVC firms are more successful than IVC firms, since IPO usually is the most favorable type of exit (Brau, Francis, and Kohers 2003; Bienz and Leite 2008; Gompers and Lerner 1997). Column 5 in Table 4.3 suggests that both the presence and the absence of a strategic fit have insignificant impacts on the hazard of M&A. It is likely that this result is driven by the noisy M&A data. The impact from a strategic fit in Table 4.1, 4.2 and 4.3 indicates that CVC firms are more likely to exit by going public, whether or not a strategic fit is present. Since IPO generally is the most profitable type of exit, these results might imply that CVC firms tend to invest by cause of financial returns rather than strategical benefits. VC centrality and VC firm age are both significant and have a positive impact on the hazard of M&A. Interestingly, the impact from the accumulated amount invested is significant but reduces the likelihood of an exit through M&A, as opposed to its positive impact on the likelihood of an IPO. While the results in Table 4.1 suggest a positive relation between the accumulated amount invested and the probability of exit, these exits are most likely to be IPOs. This is consistent with Brau, Francis, and Kohers (2003), who finds a positive relation between firm size and IPOs, and a negative relation between firm size and takeovers. A possible explanation could be the fixed costs related to an IPO (Ritter 1987). The results also suggest that the probability of exit through M&A is independent of market conditions.

4.2.2 The degree of CVC involvement

Table 4.4 reports the subhazard estimates of alternative exit outcomes, contingent on CVC-backing, treating the impeding events, bankruptcy and discontinuation as competing events. A 10 percentage point increase in the share of equity, raises the hazard of exit by 7%, significant on the 5 percent level. This effect is even more pronounced for an IPO, with a highly significant hazard ratio of 1.101. Consistent with the finding in Table 4.1, 4.2 and 4.3, that the presence of CVC does not affect the probability of M&A, an increase in the share of equity naturally has an insignificant impact as well. These results are robust for an alternative measure, defined as the number of investments made by CVC in relation to the total number of investments[1]. A strategic fit between a corporate parent and a start-up does not

[1] The results are accessible in Table 5.3 under robustness considerations.

affect the likelihood of exit, as suggested by previous regressions.

Supporting the second hypothesis, our findings suggest that it is not only the presence of CVC that adds value to a venture, but also the degree to which a CVC is involved. The contributions made by CVC seems to be amplified when a larger share of the equity invested is attributable to CVC firms. Put differently, if CVC firms shape the portfolio companies, the probability of success should be increasing with the potential to manage the start-up. However, these results are reliable only to the extent that our proxy can explain the level of control that CVC firms are assigned with. In the absence of the stakes held by each investor, we are forced to overlook the valuation at the time of the investments. Consequently, the proxy might not reflect the actual shareholdings of the investors[2]. Additionally, S. N. Kaplan and Strömberg (2003) finds that the rights in financial contracts can be separately allocated, which further complicates the matter. The insignificance in the proxy for

Table 4.4: Subhazard estimates of exits contingent on CVC involvement.
This table presents subhazard estimates of exits, contingent on CVC involvement. The competing events are defined as bankruptcy and discontinuation for regression (1), M&A, bankruptcy and discontinuation for regression (2) and IPO, bankruptcy and discontinuation for regression (3). An observation consists of a given company in a given month. The dependent variable equals zero before the case of a potential exit and equals one in the month of the exit. "Share of equity, CVC" measures the share of equity attributable to CVC firms. This variable is scaled to represent increments in 10 percentage points. "CVC investment with strategic fit" is a dummy variable taking on the value one if the investing CVC firm has a strategic fit. "Sum of patents, last five years" is the number of patent applications filed by a company over the last five years. "Sum of alliances, last five years" is the number of strategic alliances a company has experienced over the last five years. "Based in California or Massachusetts" is a dummy variable taking on the value one if a company is based in California or Massachusetts and zero otherwise. "Sum of VC rounds" measures the accumulated number of funding rounds received by a company in each month. "Accumulated amount invested" is the total equity amount invested in each month, measured in millions of dollars. "VC centrality, average" measures the average influence of all VC firms that have invested in a company at each month. "VC firm age, average" measures the average number of months since the founding of the VC firms that have invested in a company in each month. "S&P500 return, 3m" is the Standard & Poor's 500 3-month index return. The subhazard analysis is executed with robust standard errors.

	IPO or M&A (1)	IPO (2)	M&A (3)
Share of equity invested, CVC	1.070**	1.101***	1.028
CVC investment with strategic fit	1.119	1.111	1.186
Company characteristics			
Sum of patents, last five years	1.012***	1.017***	0.997
Sum of alliances, last five years	1.056	1.581**	0.820
Based in California or Massachusetts	0.986	1.001	0.973
VC characteristics			
Sum of VC rounds	1.186***	1.170***	1.118**
Accumulated amount invested	1.003***	1.005***	0.996*
VC centrality, average	1.069***	1.019	0.936**
VC firm age, average	1.000	1.000	1.001**
Market conditions			
S&P500 return, 3m	1.022***	1.036***	0.998
Number of observations	101,121	101,121	101,121
Number of companies	960	960	960

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

[2] To assess the accuracy of the proxy we examined 20 random IPO prospects and compared the stakes held by each CVC firm to the values in our data. As predicted, the stakes were not always exact but fairly in line with our calculations.

strategic fit could again be due to the heterogeneity issue. It might reluctantly include both competing and complementary business lines. The stock of patents has a positive and significant impact on the hazard of IPO, but no impact on the hazard of exit through M&A. Altogether, an additional patent increases the probability of exit by 1.2%. An additional alliance dramatically raises the hazard of an IPO by 58.1%. However, the effect is insignificant for M&A as the event of interest. The total number of rounds has a positive and significant impact in all events. The results for accumulated amount invested and the 3-month S&P500 index return are consistent with the results from Table 4.1, 4.2 and 4.3. VC centrality has a more complex interpretation. Higher centrality increases the probability of exit at the 1 percent significance level. However, neither the hazards for IPO and M&A have a positive and significant impact. In fact, VC centrality significantly decreases the hazard of M&A. This can be explained by the unreported time interaction coefficient in the regression with IPO as the outcome of interest, which is positively significant[3]. Since VC centrality is independent of time when IPO or M&A is the outcome of interest, that effect is captured in the hazard ratio of VC centrality in the corresponding regression.

[3] A positive interaction term suggests that the effect of the variable increases with time. The implications of a significant time dependent variable is analyzed in Appendix A.1. The regressions with time interactions are available upon request.

5. Robustness considerations

In this section we test and discuss the robustness of our results. We consider an alternative interpretation of the hazard ratios when the proportional hazards assumption is violated and use a different measure of the degree of CVC involvement.

5.1 An alternative interpretation of hazard ratios

If the proportional hazards assumption is violated, an alternative approach is to treat the hazard ratios as "average" ratios (Kalbfleisch and Prentice 1981).

Table 5.1: Average subhazard estimates of exit through IPO or M&A.
This table presents subhazard estimates of an exit, excluding effects of time-interacted variables. The competing events are defined as bankruptcy and discontinuation for regression (1) and (2), M&A, bankruptcy and discontinuation for regression (3) and (4) and IPO, bankruptcy and discontinuation for regression (5) and (6). Column 1-2 contains the hazard estimates of an exit through IPO or M&A, comparable to Table 4.1. Column 3-4 contains the hazard estimates of an exit through IPO, comparable to Table 4.2. Column 5-6 contains the hazard estimates of an exit through M&A, comparable to Table 4.3. "CVC investment" is a dummy variable taking on the value one in the month of an equity investment from a CVC firm and in all subsequent months. "CVC investment with strategic fit" is a dummy variable taking on the value one if the investing CVC firm has a strategic fit. "CVC investment without strategic fit" is a dummy variable taking on the value one if the investing CVC firm does not have a strategic fit. "Sum of patents, last five years" is the number of patent applications filed by a company over the last five years. "Sum of alliances, last five years" is the number of strategic alliances a company has experienced over the last five years. "Based in California or Massachusetts" is a dummy variable taking on the value one if a company is based in California or Massachusetts and zero otherwise. "Sum of VC rounds" measures the accumulated number of funding rounds received by a company in each month. "Accumulated amount invested" is the total equity amount invested in each month, measured in millions of dollars. "VC centrality, average" measures the average influence of all VC firms that have invested in a company at each month. "VC firm age, average" measures the average number of months since the founding of the VC firms that have invested in a company in each month. "S&P500 return, 3m" is the Standard & Poor's 500 3-month index return. The subhazard analysis is executed with robust standard errors.

	IPO or M&A		IPO		M&A	
	(1)	(2)	(3)	(4)	(5)	(6)
CVC investment	1.258***		1.619***		0.930	
CVC investment with strategic fit		1.073		1.388**		0.853
CVC investment without strategic fit		1.375***		1.684***		1.009
Company characteristics						
Sum of patents, last five years	1.012***	1.012***	1.018***	1.018***	0.996	0.997
Sum of alliances, last five years	1.090*	1.099*	1.137**	1.154**	0.837	0.805
Based in California or Massachusetts	0.975	0.961	0.899	0.919	1.038	1.007
VC characteristics						
Sum of VC rounds	1.117***	1.117***	1.178***	1.175***	1.126***	1.122***
Accumulated amount invested	1.003***	1.003***	1.005***	1.004***	0.996**	0.996**
VC centrality	1.062***	1.064***	1.077***	1.078***	1.008	1.013
VC firm age, average	1.001***	1.001***	1.000	1.000	1.002***	1.002***
Market conditions						
S&P500 return, 3m	1.016***	1.015***	1.033***	1.033***	0.996	0.996
Number of observations	239,879	234,549	239,879	234,549	239,879	234,549
Number of companies	2,191	2,187	2,191	2,187	2,191	2,187

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

In Table 5.1 and 5.2 we employ the Fine and Gray model with competing risks, but without interaction variables. The hazard ratios are affected by the sign and significance of the interacted variables in Appendix A.1. For example, the hazard ratio for VC centrality is higher than the point estimate in Table 4.1 since the effect of increased centrality is increasing with time, according to the interaction variable in Appendix A.1. The point estimates of the variables of interest, "CVC investment" and "Share of equity invested, CVC", are very close to the estimates in Table 4.1, 4.2 and 4.3. However, the hazard ratios for the number of alliances are substantially lower. This is explained by the negative coefficient of the interacted variable in Appendix A.1, which implies that a young company entering an alliance experiences a higher hazard of exit than does a relatively old company. A general explanation for a decreasing hazard over time is given by Giot and Schwienbacher (2007), who finds that VC-backed firms initially experience an increase in the probability of IPO, but that these firms eventually reach a plateau, followed by a diminishing hazard as time further increases. Also, consistent with Giot and Schwienbacher (2007), the hazard of M&A is less dependent on time.

Table 5.2: Average subhazard estimates of exits contingent on CVC involvement.
This table presents subhazard estimates of an exit contingent on CVC involvement, excluding effects of time-interacted variables. The competing events are defined as bankruptcy and discontinuation for regression (1), M&A, bankruptcy and discontinuation for regression (2) and IPO, bankruptcy and discontinuation for regression (3). "Share of equity, CVC" measures the share of equity attributable to CVC firms. This variable is scaled to represent increments in 10 percentage points. "CVC investment with strategic fit" is a dummy variable taking on the value one if the investing CVC firm has a strategic fit. "Sum of patents, last five years" is the number of patent applications filed by a company over the last five years. "Sum of alliances, last five years" is the number of strategic alliances a company has experienced over the last five years. "Based in California or Massachusetts" is a dummy variable taking on the value one if a company is based in California or Massachusetts and zero otherwise. "Sum of VC rounds" measures the accumulated number of funding rounds received by a company in each month. "Accumulated amount invested" is the total equity amount invested in each month, measured in millions of dollars. "VC centrality, average" measures the average influence of all VC firms that have invested in a company at each month. "VC firm age, average" measures the average number of months since the founding of the VC firms that have invested in a company in each month. "S&P500 return, 3m" is the Standard & Poor's 500 3-month index return. The subhazard analysis is executed with robust standard errors.

	IPO or M&A (1)	IPO (2)	M&A (3)
Share of equity invested, CVC	1.075***	1.103***	1.021
CVC investment with strategic fit	1.112	1.154	1.251
Company characteristics			
Sum of patents, last five years	1.012***	1.018***	0.997
Sum of alliances, last five years	1.055	1.010	0.807
Based in California or Massachusetts	0.994	1.010	0.964
VC characteristics			
Sum of VC rounds	1.122***	1.180***	1.140***
Accumulated amount invested	1.003***	1.005***	0.996**
VC centrality, average	1.074***	1.078***	0.936**
VC firm age, average	1.000	1.000	1.001**
Market conditions			
S&P500 return, 3m	1.022***	1.037***	0.998
Number of observations	101,121	101,121	101,121
Number of companies	960	960	960

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

5.2 Redefinition of the degree of CVC involvement

For some investments, the amount invested is undisclosed and for the variable "Accumulated amount invested" this simply translates to missing values. However, since the variable "Share of equity invested, CVC" is based on the amount invested it could be subject for bias, depending on the distribution of undisclosed values between IVC and CVC. The fraction of undisclosed investments for CVC and IVC firms are 7.8% and 10.1% respectively and the difference is statistically significant at the 1 percent level. This test is presented in appendix A.5.

As a robustness check, we redefine the degree of CVC involvement as the number of CVC investments in relation to the total number of investments in the start-up. We then use the model by Fine and Gray (1999) to estimate the hazard ratios presented in Table 5.3.

Table 5.3: Subhazard estimates of exits contingent on CVC involvement.
This table presents subhazard estimates of exits, contingent on CVC involvement. The competing events are defined as bankruptcy and discontinuation for regression (1), M&A, bankruptcy and discontinuation for regression (2) and IPO, bankruptcy and discontinuation for regression (3). The variable of interest is "Fraction of investments, CVC" which is defined as the number of investments from CVC in relation to the total number of investments in the start-up. "CVC investment with strategic fit" is a dummy variable taking on the value one if the investing CVC firm has a strategic fit. "Sum of patents, last five years" is the number of patent applications filed by a company over the last five years. "Sum of alliances, last five years" is the number of strategic alliances a company has experienced over the last five years. "Based in California or Massachusetts" is a dummy variable taking on the value one if a company is based in California or Massachusetts and zero otherwise. "Sum of VC rounds" measures the accumulated number of funding rounds received by a company in each month. "Accumulated amount invested" is the total equity amount invested in each month, measured in millions of dollars. "VC centrality, average" measures the average influence of all VC firms that have invested in a company at each month. "VC firm age, average" measures the average number of months since the founding of the VC firms that have invested in a company in each month. "S&P500 return, 3m" is the Standard & Poor's 500 3-month index return. The subhazard analysis is executed with robust standard errors.

	IPO or M&A (1)	IPO (2)	M&A (3)
Fraction of investments, CVC	1.067*	1.105***	1.029
CVC investment with strategic fit	1.129	1.109	1.189
Company characteristics			
Sum of patents, last five years	1.012***	1.017***	0.997
Sum of alliances, last five years	1.061	1.62***	0.830
Based in California or Massachusetts	0.981	0.999	0.964
VC characteristics			
Sum of VC rounds	1.187***	1.170***	1.119***
Accumulated amount invested	1.003***	1.005***	0.996**
VC centrality, average	1.069***	1.078***	0.936**
VC firm age, average	1.000	1.000	1.001**
Market conditions			
S&P500 return, 3m	1.022***	1.037***	0.998
Number of observations	101,121	101,121	101,121
Number of companies	960	960	960

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

For exits defined as both IPO and M&A the point estimate is similar but the significance level is lower, in comparison with the results in Table 4.4. When IPO and

M&A are treated as separate outcomes, the hazard ratios and significance levels are similar to the ones in Table 4.2 and 4.3. Since the results does not change our interpretation, the variable "Share of equity invested, CVC" is robust to the undisclosed investments.

6. Conclusions

This paper examines the impact of corporate venture capital on the hazard of exit in nascent companies, either through IPO, M&A or both. The empirical analysis indicates that the presence of CVC increases the hazard of exit in excess of IVC. However, these exits are most likely to be IPOs. This could potentially be explained by the structural differences of the investment programs in CVC firms and IVC firms. Since CVC firms, in contrast to IVC firms, lack a prespecified finite life of limited partnerships, a corporate fund might have more leeway to bring portfolio companies public when equity valuations are high. Alternatively, it is possible that CVC firms tend to invest by cause of financial returns, rather than strategical benefits. Furthermore, since the presence of CVC mainly raises the hazard of IPO, CVC firms could be more successful than IVC firms, since IPO usually is the most favorable type of exit. Our findings also suggest that CVC firms escort their portfolio companies towards an exit through active contributions, rather than simply choose to invest with respect to the quality of the portfolio company. As opposed to preceding studies, the existence of a strategic overlap between the parent company of a CVC firm and the start-up only appears to have a significant role in the going public decision. Instead, the absence of congruent strategies is indicative of an increase in the probability of both exit and IPO separately. One plausible reason is the conflicts of interest that might arise in the presence of a strategic overlap. If the parent company and the portfolio company operates within similar business areas, the probability of competing products should be greater than in the opposite case. Consistent with earlier research, receiving funding from VC firms with higher network centrality tends to increase the likelihood of exit through IPO and M&A collectively, as well as of IPO and M&A separately. This corroborates the intuition that the fruitful contribution stems from the fact that high-centrality VC firms have access to a wider range of expertise and capital.

6.1 Further research

Methodologically, the proxies for VC control and strategic overlap are both subject to improvement. First, since control and voting rights can be separately allocated in financial contracts, the number of board seats might reflect the level of control to a larger extent. This requires extensive research on the board compositions for each investment throughout the entire follow-up. Second, a strategic overlap could be more accurately defined by scrutinizing e.g. IPO prospects or annual reports. Our study can further be extended to examine the interaction between corporate and independent VCs. Due to the organizational differences, conflict of interest might arise and affect how the venture is financed. Finally, we notice a presence of heterogeneity within the corporate venture capitalists. Some firms are closely related to independent venture capitalists in the sense that these firms are financially oriented, while others have a more explicit strategic mandate. A disentanglement of this heterogeneity can provide further clarity to the role of corporate funds and the hazard of exit.

Bibliography

Ball, Eric, Hsin Hui Chiu, and Richard Smith (2011). “Can VCs time the market? An analysis of exit choice for venture-backed firms”. In: *Review of Financial Studies* 24.9, pp. 3105–3138.

Bienz, Carsten and Tore E Leite (2008). “A Pecking Order of Venture Capital Exits”. In:

Bonacich, Phillip (1972). “Factoring and weighting approaches to status scores and clique identification”. In: *Journal of Mathematical Sociology* 2.1, pp. 113–120.

Brau, James C, Bill Francis, and Ninon Kohers (2003). “The choice of IPO versus takeover: Empirical evidence”. In: *The Journal of Business* 76.4, pp. 583–612.

Chesbrough, Henry (2000). “Designing corporate ventures in the shadow of private venture capital”. In: *California Management Review* 42.3, pp. 31–49.

Cox, David (1972). “Regression models and life tables (with discussion)”. In: *Journal of the Royal Statistical Society* 34, pp. 187–220.

Cumming, Douglas (2010). *Venture capital: Investment strategies, structures, and policies*. Vol. 9. John Wiley & Sons.

Fine, Jason P and Robert J Gray (1999). “A proportional hazards model for the subdistribution of a competing risk”. In: *Journal of the American statistical association* 94.446, pp. 496–509.

Giot, Pierre and Armin Schwienbacher (2007). “IPOs, trade sales and liquidations: Modelling venture capital exits using survival analysis”. In: *Journal of Banking & Finance* 31.3, pp. 679–702.

Gompers, Paul and Josh Lerner (1997). “Venture capital and the creation of public companies: do venture capitalists really bring more than money?” In: *The Journal of Private Equity* 1.1, pp. 15–32.

— (2000). “The determinants of corporate venture capital success: Organizational structure, incentives, and complementarities”. In: *Concentrated corporate ownership*. University of Chicago Press, pp. 17–54.

Hancock, Gregory R and Ralph O Mueller (2010). *The reviewer's guide to quantitative methods in the social sciences*. Routledge.

Hellmann, Thomas (2002). “A theory of strategic venture investing”. In: *Journal of Financial Economics* 64.2, pp. 285–314.

Hochberg, Yael V, Alexander Ljungqvist, and Yang Lu (2007). “Whom you know matters: Venture capital networks and investment performance”. In: *The Journal of Finance* 62.1, pp. 251–301.

Hsu, David H and Rosemarie H Ziedonis (2008). “Patents as quality signals for entrepreneurial ventures.” In: *Academy of Management Proceedings*. Vol. 2008. 1. Academy of Management, pp. 1–6.

Ivanov, Vladimir I and Fei Xie (2010). "Do corporate venture capitalists add value to start-up firms? Evidence from IPOs and acquisitions of VC-backed companies". In: *Financial Management* 39.1, pp. 129–152.

Kalbfleisch, John D and Ross L Prentice (1981). "Estimation of the average hazard ratio". In: *Biometrika*, pp. 105–112.

Kaplan, Edward L and Paul Meier (1958). "Nonparametric estimation from incomplete observations". In: *Journal of the American statistical association* 53.282, pp. 457–481.

Kaplan, Steven N and Per Strömberg (2003). "Financial contracting theory meets the real world: An empirical analysis of venture capital contracts". In: *The Review of Economic Studies* 70.2, pp. 281–315.

Lerner, Josh (1994). "Venture capitalists and the decision to go public". In: *Journal of financial Economics* 35.3, pp. 293–316.

— (1995). "Venture capitalists and the oversight of private firms". In: *The Journal of Finance* 50.1, pp. 301–318.

Masulis, Ronald W and Rajarishi Nahata (2009). "Financial contracting with strategic investors: Evidence from corporate venture capital backed IPOs". In: *Journal of Financial Intermediation* 18.4, pp. 599–631.

McNally, Kevin (1997). "Corporate Venture Capital". In: *Bridging the equity gap in the small business sector,(London).*

Ozmel, Umit, David T Robinson, and Toby E Stuart (2013). "Strategic alliances, venture capital, and exit decisions in early stage high-tech firms". In: *Journal of Financial Economics* 107.3, pp. 655–670.

Ritter, Jay R (1987). "The costs of going public". In: *Journal of Financial Economics* 19.2, pp. 269–281.

Santhanakrishnan, Mukunthan (2002). "The impact of complementarity on the performance of entrepreneurial companies". In: *Unpublished manuscript, Arizona State University.*

Sørensen, Jesper B and Toby E Stuart (2000). "Aging, obsolescence, and organizational innovation". In: *Administrative science quarterly* 45.1, pp. 81–112.

Stuart, Toby E, Ha Hoang, and Ralph C Hybels (1999). "Interorganizational endorsements and the performance of entrepreneurial ventures". In: *Administrative science quarterly* 44.2, pp. 315–349.

A. Appendix

A.1 Test of the proportional hazards assumption

In Table A.1 and A.2 we test the proportional hazards assumption by employing the Fine and Gray (1999) model, letting each variable be interacted with time. For the assumption to hold, the interaction coefficients should not be different from zero.

Table A.1: This table reports the coefficients of each independent variable interacted with time. The dependent variable is an exit via IPO or M&A. For the proportional hazards assumption to hold, the slope coefficients should not be different from zero.

	(1)	(2)
CVC investment	0.998	
CVC investment with strategic fit		1.000
CVC investment without strategic fit		0.999
Company characteristics		
Sum of patents, last five years	1.000*	1.000
Sum of alliances, last five years	0.997**	0.997**
Based in California or Massachusetts	1.001	1.001
VC characteristics		
Sum of VC rounds	0.999***	0.999***
Accumulated amount invested	1.000	1.000
VC centrality	1.000***	1.000***
VC firm age, average	1.000	1.000
Market conditions		
S&P500 return, 3m	1.000	1.000
Number of observations	239,879	234,549
Number of companies	2,191	2,187

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

The test shows that the variables "Sum of VC rounds", "Sum of alliances, last five years" and "VC centrality" violates the assumption. Since the data suggests that the effect depends on time, a given number of VC rounds, alliances and centrality has one effect for low values of time but a different effect for high values of time. The number of VC rounds and alliances has a greater impact on the probability of an IPO or M&A for relatively young start-ups than for old start-ups. The opposite is true for the variable "VC centrality". This might have an intuitive explanation, but we choose not to elaborate on it. Instead, we revert to the fact that including an interaction term is both a diagnostic test as well as a technique of taking the effect into account (Hancock and Mueller 2010). Also, the economic significance of the coefficients are very low. An alternative approach is to exclude the interaction variables and treat the hazard ratios as "average" effects over time (Kalbfleisch and Prentice 1981), which is carried out in the robustness section.

Table A.2: This table reports the coefficients of each independent variable interacted with time. The dependent variable is an exit via IPO or M&A for CVC-backed companies only. For the proportional hazards assumption to hold, the slope coefficients should not be different from zero.

	(1)
Share of equity, CVC	0.999*
CVC investment with strategic fit	0.998
Company characteristics	
Sum of patents, last five years	1.000
Sum of alliances, last five years	0.997*
Based in California or Massachusetts	0.998
VC characteristics	
Sum of VC rounds	0.999***
Accumulated amount invested	1.000
VC centrality, average	1.000
VC firm age, average	1.000
Market conditions	
S&P500 return, 3m	1.000
Number of observations	101,121
Number of companies	960

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

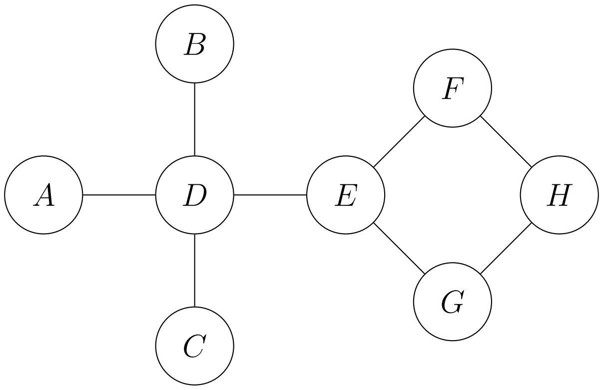
A.2 Biotechnology SIC codes

283: Drugs
384: Surgical, Medical, and Dental Instruments and Supplies
807: Medical and Dental Laboratories
873: Research, Development, and Testing Services

A.3 Eigenvector centrality example

We consider a network consisting of seven venture capitalists, labeled from A-H. The relationships from the syndication history of these venture capitalists are illustrated graphically in Figure A.1.

Figure A.1: A 7-actor network of venture capitalists. The venture capitalists are illustrated as vertices labeled from A-H and the syndication history is illustrated by undirected edges connecting the vertices.



The network corresponds to an adjacency matrix accessible in Table A.3, in which the presence or the absence of a co-investment relationship is denoted by one or zero, respectively. The symmetry of the matrix illustrates the undirected relationships in the network.

Table A.3: Adjacency matrix

	A	B	C	D	E	F	G	H
A	0	0	0	1	0	0	0	0
B	0	0	0	1	0	0	0	0
C	0	0	0	1	0	0	0	0
D	1	1	1	0	1	0	0	0
E	0	0	0	1	0	1	1	0
F	0	0	0	0	1	0	0	1
G	0	0	0	0	1	0	0	1
H	0	0	0	0	0	1	1	0

From the adjacency matrix, we are able to calculate two different measures of centrality, reported in Table A.4. First, by summing each row (or column) we arrive at the *degree* centrality. This measure simply counts the number of unique venture capitalists, with which a venture capitalist has co-invested. Since the degree measure alternates with the size of a network, it is important to use normalization in order to ensure comparability. This is carried out by dividing each degree with the maximum number of ties possible, $n - 1$. As indicated by Table A.4, venture capitalist D unsurprisingly has the highest degree centrality, while A, B and C have the lowest.

Second, we calculate an alternative centrality measure, which amplifies the explanatory power of the degree centrality, called the *eigenvector* centrality (Bonacich 1972). In excess of the degree measure, this measure takes into account the centralities of the venture capitalist each venture capitalist has a connection to. As opposed to the

Table A.4: Normalized degree and eigenvector centralities

VC	Normalized *degree*	Normalized *eigenvector*
A	14.3%	30.4%
B	14.3%	30.4%
C	14.3%	30.4%
D	57.1%	70.7%
E	42.9%	73.4%
F	28.6%	50.0%
G	28.6%	50.0%
H	28.6%	43.0%

setting of degree, in which the measure reflects the number of actors an actor is associated with, the eigenvector centrality captures the level of influence attributed to an actor. Technically, the centralities are calculated by taking the elements of the eigenvector corresponding to the largest eigenvalue of the adjacency matrix (Hochberg, Ljungqvist, and Lu 2007). These elements are then normalized by division of the theoretical maximum eigenvector centrality in a network of seven actors. As opposed to the degree measure, by taking the quality of the relationships into account using the eigenvector measure, venture capitalist E is the most central actor. Despite the fact that venture capitalist D has a higher number of co-investment relations, the connections of venture capitalist E have higher centralities than the connections of venture capitalist D. Furthermore, venture capitalist H now has a lower centrality than F and G, reflecting the fact that these two actors are closer to the most central actor in the network.

A.4 Log-rank test

Table A.5: Log-rank test for equality of survivor functions

	Events observed		Events expected
IVC	516		565.99
CVC	481		431.01
Total	997		997.0
	chi2 (1)	=	10.39
	Pr>chi2	=	0.0013

A.5 Two-sample test of proportions

Table A.6: Two-sample test of proportions

	Mean	Std. Err.	P> $\|z\|$
Undisclosed, CVC	0.078	0.005	
Undisclosed, IVC	0.101	0.002	
Difference	-0.023		0.001