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On venture capital exit dynamics

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Abstract

This paper uses a competing risks model with time-varying covariates to study the duration of venture capital (VC) investments among U.S.-based VC-backed entrepreneurial start-ups. We specifically analyze the dynamics of venture capital funding, investment syndication, and financial market conditions throughout VC investment duration and then link these variables to the different exit outcomes. Parameter estimates from our models confirm that our approach provides refined evidence for the determinants of VC exit dynamics. We find that the VC incubation period is the shortest for single-round syndicated investments. Among portfolio companies receiving VC through multiple rounds, the fastest initial public offerings (IPOs) occur in booming technological industries for which VC firms provided deep pockets at the exit. In contrast, the quickest trade sales occur for the firms where venture capitalists eased the initial cash constraints of the portfolio companies and decreased their financing thereafter. In addition, improved liquidity conditions over the course of investment duration are likely to delay VC write-offs.

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1. Introduction

Venture capitalists or venture capital firms (later, VCs) are financial intermediaries that raise funds (venture capital, later, VC) from institutional investors and high-net-worth individuals and channel these funds as long-term equity stakes into innovative, high-tech start-ups. These start-ups typically face significant technological and market-related uncertainties and are therefore too risky to be financed by ordinary bank loans. VCs mitigate the risk of investment failure in several ways, including careful deal selection, active involvement in the company's strategic decision-making and value-adding processes[1] (Botazzi et al., 2008; Davila et al., 2003; Hellmann and Puri, 2002), syndication of investments with other VCs (Bubna et al., 2020; Brander et al., 2002; Das at al., 2011; Hochberg et al, 2007; Gompers et al., 2016; Lerner, 1994;), and/or spreading the capital across several financing rounds (a strategy known as staged financing) (Bergeman and Hege,1998; Chemmanur and Tian, 2019; Cornelli and Yosha, 2003; Gompers, 1995; Sahlman, 1990; Sorensen, 2007; Wang and Zhou, 2004). At each stage of financing, VCs evaluate portfolio companies' prospects and adjust their investment decision to the degree of asymmetric information involved in them. This implies allocating more capital to support the investee's continued growth or cutting the financing and liquidating the unpromising venture.

Previous literature shows that VCs also adjust their investment decision based on the liquidity risk and overall market conditions (Black and Gilson, 1998; Cumming et al., 2005; Gompers, 1995;). In illiquid markets, VC firms are more likely to syndicate their investments (Cumming et al., 2005) and also more likely to postpone their exit by investing more in high-tech, early-stage companies. Conversely, in highly liquid initial public offering (IPO) markets, VCs rush to exit by investing in later-stage projects.[2] Among the successful exit options, the most used exit channels are IPO and private sale of a company (also called trade sale) via merger or acquisition by another company. IPO normally generates a higher price and allows entrepreneurs to maintain their control rights. However, the exit procedures involved in a trade sale tend to be cheaper than an IPO and often faster and simpler.

In this study, we provide a model of the VC exit process that captures the full timeline of funding, VC syndication, and financial market conditions over the course of investment duration. Although previous studies have provided evidence for how each of these variables may affect VC exit outcomes, none have holistically captured the dynamics of these variables over the course of the investment period. We believe that VC financing, syndication profile and financial market conditions are interdependent. For example, liquidity conditions in the market may determine VCs' willingness to engage in a new syndicate or the amount of capital invested by a VC syndicate at each financial round. In addition, depending on the market conditions, VCs may also choose between different financing scenarios: they may either invest relatively small amounts of capital at each round of financing and employ more financial rounds for a given portfolio company or alternatively, allow longer waiting times between subsequent financial rounds and invest larger amounts of capital each time. Therefore, we believe that jointly capturing the full dynamics of

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[1] Venture capitalists (VCs) perform several typical tasks for their investee firms: assess and revise business plans, formulate business strategies, hire key managers and other professional personnel, provide business contacts, and arrange additional financing from outside investors. (Bottazzi, et al., 2008)

[2] Exit allows VCs to recycle their nonfinancial contributions from successful firms to early-stage start-ups. The choice of exit option can have important implications for a VC's activity: for example, successful cash-outs from previous investments generate prestige and guarantee success in future fundraising, whereas a failure to exit or liquidation of an investment can damage the VC's reputation and therefore jeopardize their follow-up fundraising chances. (Gejadze et al., 2017).

these variables may provide a better understanding of the link between the financing patterns of the portfolio companies and the VC exit process.

We start by modeling investment duration via survival analysis. Specifically, we use a competing risks model with time-varying covariates, which provides a powerful model for differentiating among the VC exit outcomes for entrepreneurial firms with distinct patterns in VC funding or investment syndication. In contrast to the fixed covariates framework used in similar studies, it incorporates in the analysis information on the amount of capital invested at each financial round, the time elapsed between subsequent financial rounds, the number of VCs engaged in syndicate financing each financial round, and the capital market conditions before the corresponding financing round.

Overall, our results suggest that accounting for the full timeline of venture capital investment and market characteristics provides more precise evidence on how these variables affect VC exit dynamics. In the following section, we outline the specific contributions of our study by explaining the time-varying covariates framework of the competing risks model. Section 3 then describes the data and variables used in our empirical model, and Section 4 presents our estimation results. We review our findings and provide a brief conclusion in Section 5.

2. Modeling VC exit

Previous literature on the VC exit process has examined either the different exit options (i.e., IPO, trade sale, or liquidation) or/and the investment duration (Giot and Schwienbacher, 2007; Gompers, 1995; Cumming and Macintosh, 2001; Lerner, 1994). In these studies, the VC investment duration has been usually modeled using a fixed covariates framework - as a function of several covariates that are fixed at the beginning of the investment and remain constant throughout the investment period. While this assumption of constancy is true for some investment characteristics, such as the industry being invested in or the geographical location of a portfolio firm, it does not hold for others. For example, as firms move up the ladder of staged financing, the amount of venture capital invested in the portfolio company increases, the composition of the syndicate financing the portfolio company may evolve, and IPO and stock market conditions can change. Overall, changes in these variables can create distinct incentives for VCs to exit their investments. We believe that ignoring the full dynamics of financing from the first to the last financial round in a portfolio company or assuming that the timing of funding has no impact on the exit outcome may lead to biased estimation results. From the finance theory perspective, the time of financing has an important implication for the purpose of financing. For example, if early-stage financing eases the cash constraint of a company and is pivotal for the growth of a start-up, second-round financing may support the investments in working capital, while the last-round financing adjusts the equity stakes in the portfolio company between different stakeholders of the firm and finances the cost of exit (IPO underwriting costs, legal costs, IPO prospectus, etc). While the fixed covariates framework examines the overall impact of the amount of financing on the exit option, the time-varying covariates framework may additionally differentiate between the financing patterns critical for quicker exit via each exit route and hence, provide a better understanding of the link between alternative financing scenarios and VC exit process.

To account for the full dynamics of venture capital financing, we model investment duration using the competing risks model of the survival analysis. In our model, we define investment duration as the time elapsed between the date a portfolio firm received its first VC round till the date of VC exit. For active investments from which VC has not yet exited, the investment period is treated as right censored and defined as the time between the date a portfolio firm received its first VC round and the date of the last observation in the sample. The strength of using survival analysis for modeling the VC investment period is that the analysis incorporates these right-censored periods; in other words, it explicitly accounts for the information provided by VC firms that have not yet exited from portfolio companies. The general approach and estimation procedure for survival analysis and competing risks models are described by Giot and Schwienbacher (2007), Box-Steffensmeier and Jones (2004) and Lee and Wang (2003). Below we explain the time-varying covariates framework that allows us to account for the full timeline of the financing and associated changes in investment or market characteristics.

A competing risks model delivers cause-specific hazard rates. In our case, the cause-specific hazard rate refers to the conditional probability of an exit (via one of the possible exit options) given the time elapsed from the first VC round. Formally, the cause-specific hazard rate λ can be represented as:

$$\lambda_k(t,x) = \lim_{dt\to 0} \frac{\Pr\{t \le T \le t+dt,\ K=k|T \ge t, x\}}{dt}$$

where t is the actual duration of the investment and a realization of a continuous random variable T , x represents the covariates that influence the exit type and timing, and K is the set of possible exit options (IPO, trade sale, or liquidation).

The time-varying covariates framework differentiates between two broad types of model covariates: those that stay constant over time (Y) and those that can change across the duration of the investment $(Z(t))$. This framework further divides the investment duration t into l adjacent, non-overlapping segments of time. In our model, each time segment corresponds to the period from the previous financial round to the next one. We let $t_0 = 0$ and $t_0 < t_1 < \cdots t_j < \cdots < t_l$. Within each subinterval t_{j-1} to t_j, the covariates in Y and $Z(t)$ are fixed. However, the covariates in Y remain constant across all financial rounds (subintervals), while the covariates in $Z(t)$ can change between rounds. We fix the time-varying covariates $Z(t)$ at the beginning of each new subinterval. The hazard function for the exit direction k during sub-period j is represented by:

$$\lambda_k(t_j, Y, Z(t_j)) = \lim_{\Delta t\to 0} \frac{\Pr\{t_j \le T \le t_j+\Delta t,\ K=k|T \ge t, Y, Z(t_j)\}}{\Delta t}$$

The corresponding survival function, which represents the probability of the investment surviving beyond t_j as a function of survival up to t_{j-1} and the path taken by Y and Z up to t_j, is modeled by:

$$S_k\left(t_j, Y, Z(t_j)\right) = \Pr\left([T > t_j|T > t_{j-1}, Y, Z(t_{j-1})\right)] = e^{-[\int_{t_{j-1}}^{t_j} \lambda_k\left(s_j|Y,Z(t_{j-1})\right)ds]}$$

The overall survival function for the investment surviving beyond the duration t_l for a given exit outcome k becomes:

$$S_k(t_l, Y, Z(t_l)] = \prod_{j=1}^{l} S_k(t_j, Y, Z(t)) = e^{-\int_{t_0}^{t_1} \lambda_k(s_j|Y,Z(t_0)ds)} \ldots e^{-\int_{t_{l-1}}^{t_l} \lambda_k(s_j|Y,Z(t_{l-1})ds)}$$

$$= e^{-\sum_{j=1}^{l} \int_{t_{j-1}}^{t_j} \lambda_k\left(s_j\middle|Y,Z(t_{j-1})\right)ds)}$$

where $t_0 = 0$. The corresponding hazard function is given by:

$$\lambda_k(t_l, Y, Z(t_l)] = \prod_{j=1}^{l} \lambda_k(t_j, Y, Z(t_j)) = \prod_{j=1}^{l} \lim_{\Delta t\to 0} \frac{\Pr\{t_j \le T \le t_j+\Delta t,\ |T \ge t, Y, Z(t_j)\}}{\Delta t}$$

The overall likelihood function for observing k outcome will therefore be given by:

$$L = \prod_{i=1}^{n} f_k(t_{il}, Y_i, Z_i(t_l))^{\delta_{ik}} S_k(t_{il}, Y_i, Z_i(t_l))^{1-\delta_{ik}}$$

where $f_k(t_{il}, Y_i, Z_i(t_l)) = \lambda_k(t_{il}, Y_i, Z_i(t_l)) S_k(t_{il}, Y_i, Z_i(t_l))$. In this equation, $\delta_{ik} = 1$ if the VC exited from portfolio firm i via exit route k, and $\delta_{ik} = 0$ if otherwise. As shown in this equation, uncensored observations contribute to the likelihood via the density function, whereas censored observations contribute to the likelihood via the survival function. For example, if we maximize the likelihood for the IPO outcome (k = IPO), firms that exited via an IPO will contribute to the likelihood via the density function, whereas firms that have exited via trade sale or liquidation, as well as firms that have not yet exited, will contribute via their survival function.

Following Giot and Schwienbacher (2007), we model exit times using the generalized gamma density function because time-to-exit exhibits a hump-shaped hazard. To account for the repeated observations per firm, we use robust standard errors and adjust the variance of the parameter estimates by clustering observations on the entrepreneurial firm level.

3. Data and the descriptive analysis

To assess the benefits of our time-varying methodological framework relative to the time-invariant approach, we used the same sample data as Giot and Schwienbacher (2007). They used a competing risks model with fixed covariates to analyze the time to IPO, trade sale, or liquidation for U.S. VC-backed firms. The data covers a total of 17,780 investment rounds for 5,255 distinct venture-backed firms and spans from January 1, 1980 until June 23, 2003. The data was taken from VentureXpert, which provides information on venture capital funds and their investee firms, and Jay Ritter's website, which offers the data on the annual number of IPOs done in the U.S. market.

We informally divide all the variables used in our analysis into two categories. The first category includes all the time-varying covariates, such as the VC investment characteristics and the market conditions. These covariates can vary across financial rounds. Using these time-varying covariates, we calculated an additional group of variables to capture distinct patterns in the dynamics of VC funding and syndication across the investment duration. Our second broad category of covariates includes all the fixed (unchanging) variables, such as the technological stage and industry of the portfolio firm, the geographic location of a portfolio firm, the geographical location of a VC firm and the proximity of a VC firm to corresponding portfolio firm. Since Giot and Schwienbacher (2007) already describe how the time-invariant variables affect VC exit dynamics, we do not report the effects of these variables in our study. The variables employed in the study are explained in Table 1.

Table 2 shows that our initial sample consists of 17,780 observations, including 1,330 single-round investments and 16,450 multi-round investments. Most of the entrepreneurial firms in the sample operate in the computer industry, although the internet and the communications/media industries are also common. According to panel A of Table 2, across all industry categories, trade sale is the most common route for a VC firm to exit. The only exception is the biotechnological industry, for which the most frequent exit route is an IPO. Panel B of Table 2 shows that the *Low_low* investment strategy is, by far, the most widespread funding profile of the three funding profiles we consider. Among the other two funding profiles, the *Low_high* approach is about twice as common as the *High_low* funding profile.

Table 1. Variable definitions.
Data source: Thomson Financial SDC VentureXpert, unless noted otherwise.

Variable	Definition
Dependent variables:	
Duration	Number of days elapsed between the first VC round in a given portfolio firm and the date of VC exit via any exit route (IPO, trade sale, or liquidation). If the VC did not exit before the end of the data set, the duration is censored on June 23, 2003.
IPO	Dummy variable. Equal to one if the VC exited from the portfolio firm via IPO, and zero otherwise.
Trade sale	Dummy variable. Equal to one if the VC exited from the portfolio firm via trade sale, and zero otherwise.
Liquidation	Dummy variable. Equal to one if the VC exited from the portfolio firm via liquidation, and zero otherwise
Fixed variables:	
Portfolio firm stage	Set of five dummy variables. A variable is equal to one if the portfolio firm is in the given technological stage, and zero otherwise. We defined five stages: early, expansion, later, buyout-acquisition, and other.
Portfolio firm industry	Set of seven dummy variables. A variable is equal to one if the portfolio firm operates in the given industry, and zero otherwise. There are seven industry groups in our data: internet, biotech, computer, semiconductor, medical, communication/media, and other.
Geographical location of the portfolio firm	Set of dummy variables indicating the geographic location of the portfolio firm: WEST (California), NORTHEAST (Massachusetts, New York, and Pennsylvania), SOUTH (Texas) and MIDWEST (Illinois and Ohio). Value is 1 if the firm is located in that region and 0 otherwise.
Geographical location of the VC firm	Set of dummy variables indicating the geographic location of the VC firm: WEST (California), NORTHEAST (Massachusetts, New York, and Pennsylvania). Value is 1 if the firm is located in that region and 0 otherwise.
Proximity of the entrepreneurial firm to the VC firm	Dummy variable indicating the geographic relationship between the portfolio firm and the VC firm; equal to 1 if at least one VC firm in the syndicate is in the same U.S. state as the portfolio firm.
Time-varying variables	
Amount	Amount of capital invested in a portfolio firm during a given financial round (in USD millions).
Syndicate size	Number of VCs participating in a given financial round.

Age_oldest_VC	Age of the oldest VC firm participating in the given financial round. Age is calculated as the number of years elapsed between the incorporation date of the VC firm and the date of the corresponding financial round.
Number of IPOs	Number of IPOs issued in the U.S. market during the year preceding a given financial round.
Dynamics in funding	
Single round	Dummy variable. Equal to one if a portfolio firm received only one VC round of funding, and zero otherwise.
Low_high	Dummy variable. Equal to one if less than 20% of the total capital invested in the portfolio firm was allocated in the first financial round and more than 50% was invested during the last financial round. Equal to zero otherwise.
High_low	Dummy variable. Equal to one if more than 50% of the total capital invested in a portfolio firm was allocated in the first financial round and less than 20% was invested in the last round. Equal to zero otherwise.
Low_low	Dummy variable. Equal to one if the portfolio company received less than 20% of total capital in both the first and the last financial rounds. Equal to zero otherwise.
Dynamics in syndication	
Low_high_synd	Dummy variable. Equal to one if there were more VCs participating in the last financial round than in the first financial round.

Table 2. Summary statistics.

Exit frequencies are shown across industries and distinct funding profiles. The variables in the first column are defined in Table 1.

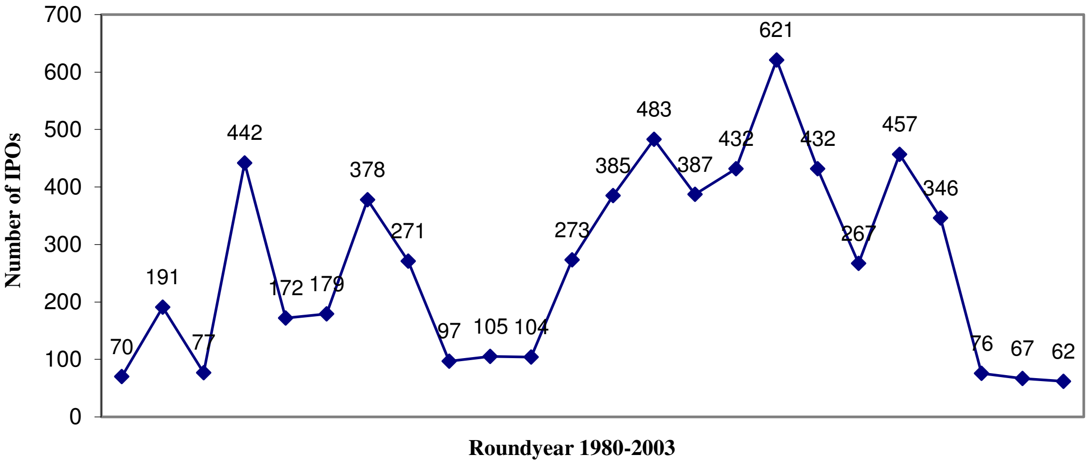
Variables	Obs	Exit routes (%)			
		IPO	Trade sale	Liquidation	Active
Full Sample	17780	27.5	47.5	8.2	16.8
Single round investments	1330	34.1	54.1	7.6	4.1
Multiple round investments	14309	25.7	44.1	7.6	22.6
Panel A. Industry by exit routes					
Internet	2573	28.6	43.1	23.7	4.6
Biotech	1167	43.6	34.6	2.8	19
Computer	5341	23.3	50.5	4.2	22
Semic	1457	37.3	49.6	6.8	6.4
Medical	2220	28.1	41	4.9	26.1
Communications/media	2587	26.2	56.4	11.1	6.4
Other industry	2435	23	46.7	6.8	23.5
Panel B. Funding and syndication profiles by exit routes					
Low_high	714	34.8	50	10.9	4.3
High_low	327	21.2	45.5	10.6	22.7
Low_low	4177	19.6	36.1	6.5	37.8
Other	9091	27.7	47	7.6	17.7

Table 3 provides a breakdown of *Amount, Syndicate size*, and *Duration* categorized by exit type, financial round number, and portfolio industry. Panel A shows that *Amount* and *Syndicate size* increase with each subsequent investment round. This is further confirmed in Panel C, which shows that portfolio firms in the earlier stages of financial development receive fewer capital commitments compared to those in later stages.

Furthermore, Panel B of Table 3 demonstrates that internet firms are the most amply funded entrepreneurial industry (to $11.4 million), followed by the communication/media ($8.5 Finally, Table 3 shows that, on average, liquidations occur earlier than successful exits: liquidated firms have an average *Duration* of less than 3 years (1,177 days), while firms that exited via IPO or trade sale have durations equal to about 3 years (1,213 days) and 4 years (1,588 days), respectively. Firms that go public are also characterized by greater syndication (around 4 VCs in syndicate) than investments exited via other exit options.

With respect to market liquidity conditions, Figures 1 display the annual *Number of IPOs* in our sample. As shown, IPO market was highly volatile between 1980 and 2003. The maximum *Number of IPOs* was observed in 1995, after which the number of IPOs declined sharply to its minimum in 2003. This trajectory stems from the dot-com-bubble and corresponding burst that occurred during this period.

Figure 1: ***Number of IPOs***
Source: Jay Ritter



4. Estimation Results

In this section, we present the parameter estimates from our models. We first compare exit outcomes of single-round investments to those of multiple-round investments using the following model:

$$\ln(t_k) = \alpha_0 + \alpha_1 Amount + \alpha_2 Syndicate\ size + \alpha_3 Age\ oldest\ VC + \alpha_4 Number\ of\ IPOs + \rho_1 Single\ round + \boldsymbol{\beta}\ Fixed\ variables + e \quad (1)$$

where t_k is the variable *Duration*, which is predicted as a function of *Amount, Syndicate size, Age oldest VC, Number of IPOs, Single round*, and *Fixed variables* as defined in Table 1.

Table 4 shows the estimation results for the *IPO, Trade sale* and *Liquidation* exit outcomes in our competing risks model with time-varying covariates. Our framework produces

Table 3. Mean statistics for duration, amount, and syndicate size as a function of the number of rounds and portfolio firm industry.

The variables are described in Table 1.

Variable	Total		IPO			Trade sale			Liquidation		
	Amount	Synd. size	Duration	Amount	Synd. size	Duration	Amount	Synd. size	Duration	Amount	Synd. size
Panel A: Frequency of each exit route by investment round											
1st round	5.9	3.0	1602	4.8	3.3	1936	4.5	3.2	1306	8.7	3.4
2nd round	7.3	3.8	1340	5.4	4.1	1654	5.6	4.1	695	14.8	4.0
3rd round	8.4	4.3	1143	7.5	4.7	1537	6.6	4.5	511	20.9	4.3
4th round	8.5	4.4	1001	8.7	5.1	1437	6.0	4.4	567	21.8	4.7
5th round	7.4	4.3	914	8.2	4.7	1439	5.1	4.3	346	17.8	4.7
Panel B: Frequency of each exit route by industry											
Internet	11.4	3.7	669	10.8	3.9	1024	10.1	3.6	740	14.6	3.8
Biotech	6.3	3.9	1141	6.5	4.0	1984	4.0	4.0	1354	14.4	4.3
Computer	5.4	3.9	1259	4.8	4.1	1518	4.4	4.2	1172	7.9	4.3
Semic	6.5	4.1	1701	4.2	4.6	1735	5.2	4.2	1549	6.3	3.6
Medical	5.2	3.8	1179	5.0	4.4	1705	3.6	3.8	1619	3.9	3.8
Com/media	8.5	4.1	1184	7.9	4.6	1608	5.7	4.0	1305	14.0	4.8
Other	5.7	3.0	1319	7.2	3.9	1806	5.0	3.3	1436	8.2	3.5
Total	6.9	3.8	1213	6.3	4.2	1588	5.2	4.0	1177	10.9	4.1

several results that differ from those obtained by Giot and Schwienbacher (2007), who use a time-invariant approach. For example, increase in *Syndicate size* does not significantly alter the time to IPO. In other words, more VCs in a syndicate does not translate to better exit outcomes. This finding suggests that VC syndication, despite its benefits, may come with some associated costs (Gompers et al., 2016). If severe enough, these costs may totally counterbalance the value-adding benefits of syndication. Indeed, our estimation results show that liquidation of a portfolio firm is delayed when *Syndicate size* increases. In this case, the different partners in a larger syndicate may have conflicting views on the future prospects of their deals, which would translate into postponed liquidations of the non-profitable projects.

Table 4. Single-round investments and time to exit via IPO, trade sale, or liquidation.

Estimated coefficients for the competing risks model with time-varying covariates. The sample includes both single round and multiple-round investments. The dependent variable is *Duration*, which ends with an IPO, trade sale, or liquidation of a portfolio firm. *Duration* is defined as the number of days elapsed between the first VC round and either (i) the date of the VC exit from the portfolio firm or (ii) June 23, 2003, whichever is earlier. Columns 1-3 display the estimated coefficients for the base model, which also controls for the *Fixed variables* including stage, industry, and the geographic location of the portfolio company and the VC firm, as well as the VCs' proximity to the portfolio company. Columns 4-6 additionally control for the interaction terms *Amount_single round* (i.e., the interaction between *Amount* and *Single round*) and *Syndicate_single round* (i.e., the interaction between *Syndicate size* and *Single round*). All the other variables used in these models are explained in Table 1. Significance at the 1%, 5%, and 10% confidence levels is denoted with *** , **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	IPO	Trade sale	Liquidation	IPO	Trade sale	LIQUID
Amount	-0.012***	-0.002	-0.029***	-0.013**	-0.001	-0.036**
Syndicate size	-0.011	0.019*	0.07***	0.007	0.025*	0.097**
Age oldest VC	0.008*	-0.002	-0.016**	0.007	-0.002	-0.016*
Number of IPOs	-0.002***	-0.001***	0.001***	-0.002**	-0.001**	0.001*
Single round	-0.662***	-0.219***	0.021	-0.055	0.003	0.34
Amount_single round				0.005	-0.003	0.032*
Syndicate_single round				-0.16**	-0.08**	-0.21**
Fixed variables	Y	Y	Y	Y	Y	Y
ln_ σ	0.551***	0.055	0.755***	0.550***	0.056	0.765***
κ	-0.012	0.398***	-0.479	-0.038	0.387***	-0.489
Observations	17780	17780	17780	17780	17780	17780

In addition, the negative parameter estimate for *Number of IPOs* (see Table 4) indicates that favorable market conditions, as evidenced by a more liquid IPO market, can also delay liquidations. [3] This finding contradicts the findings of Giot and Schwienbacher (2007) and implies that VC firms may purposefully delay liquidation of a non-successful start-up, thereby avoiding any public indication to the market that they made a poor investment decision. Announcing such an outcome to a booming market could otherwise jeopardize their fundraising chances.

[3] These findings are further strengthened when we explore the connection between favorable dynamics in the market liquidity conditions over the course of the investment duration (measured by the relative increase in the number of IPOs at the last financial round compared to the first financial round) and the VC exit outcome. To avoid repetition, we do not report these results in the paper. For robustness, we also explored the impact of alternative measures of the financial market conditions such as stock market returns measured by the annual Nasdaq returns or annual S&P500 returns prior to a corresponding round of financing. We obtained qualitatively similar results.

With respect to exit outcomes as a function of the distinct financing strategies, Table 4 shows that single-round investments exit faster than multiple-round investments. Indeed, the parameter estimate for *Single round* suggests that single-round investments are 66% shorter than deals that received capital through a staged-financing scheme. We additionally control for the interaction terms *Amount_single round* (i.e., the interaction between *Amount* and *Single round*) and *Syndicate_single round* (i.e., the interaction between *Syndicate size* and *Single round*). Results reported in columns 4-6, show that faster exits from single-round investments are more likely to be explained by the syndicated nature of these deals rather than by the amount of capital invested in these projects.

4.1 VC funding dynamics

In this subsection we explore the VC exit options from entrepreneurial firms with distinct patterns in staged financing. We compare the exit outcomes of firms that were more amply funded in their first round compared to the last round to the exit outcomes of firms that received most of their capital in their last financing round. This distinction is important, since as explained in Section 2 the purpose of funding will vary across financing rounds.

We estimate the following regression:

$$\ln(t_k) = \alpha_0 + \alpha_1 Amount + \alpha_2 Syndicate\ size + \alpha_3 Age\ oldest\ VC + \alpha_4 Number\ of\ IPO + \rho_1 Lowhigh + \rho_2 Highlow + \rho_3 Lowlow + \boldsymbol{\beta}\, Fixed\ variables + e \qquad (2)$$

where t_k is the variable *Duration* (as defined in Section 3) and *Amount, Syndicate size, Age oldest VC, Number of IPOs, Low_high, High_low,* and *Low_low* and $Fixed\ variables$ as defined in Table 1.

Table 5 displays the estimation results for Eq. (2) for the *IPO*, *Trade sale* and *Liquidation* exit outcomes. Columns 1-3 show that the *Low_high* funding profile translates into a shorter time to successful exit, whereas the *Low_low* funding profile is associated with a delay in successful exits. Our results imply that ample financing at an exit may be critical for exiting via IPO while the quickest trade sales occur for the firms where VCs eased the initial cash constraints of the portfolio companies and decreased their financing thereafter as shown by the parameter estimates of the *High_low* funding profile in column 2 of Table 5.

We further compare the link between alternative financing scenarios and VC exit outcomes across different industries. For this purpose, we control for the interaction terms between the different funding profiles and our dummy variables representing the industry of the portfolio company. In Table 5, Columns 4-6 and 7-9 present results for the internet and computer industries, respectively. The parameter estimate for *Low_high_internet* suggest that VC exit from the internet industry is more sensitive to the *Low_high* funding profile than any other industry. Our findings imply that the internet firms with a *Low_high* funding profile are listed on the stock market 61% faster than other firms. Finally, Columns 7-9 in Table 5 indicate that the link between VC exit dynamics and the different funding scenarios is not significantly different in computer firms relative to other industries.

4.2 VC syndication dynamics

In this subsection, we analyze the connection between VC syndication dynamics and VC exit outcomes. This is achieved by estimating the following regression:

Table 5.VC funding dynamics and time to exit via IPO, trade sale or liquidation

Estimated coefficients for the competing risks model with time-varying covariates. The sample covers investment rounds for portfolio firms that received VC funding via a staged financing scheme. The dependent variable is *Duration*, which ends with an IPO, trade sale, or liquidation of a portfolio firm. *Duration* is defined as the number of days elapsed between the first VC round and either (i) the date of the VC exit from the portfolio firm or (ii) June 23, 2003, whichever is earlier. Columns 1-3 display estimated coefficients for the base model, which also controls for the *Fixed variables* including stage, industry, and the geographic location of the portfolio company and the VC firm, as well as the VCs' proximity to the portfolio company.. Columns 4-6 additionally control for *Low_high_inter, High_low_inter,* and *Low_low_inter*, which are the interaction terms created by the interactions between funding profiles (*High_low/Low_high/Low_low*) and the dummy variable for the internet industry. Columns 7-9 control instead for *Low_high_comp, High_low_comp,* and *Low_low_comp*, which are interaction terms between funding profiles (*High_low/Low_high/Low_low*) and the dummy variable for the computer industry. The variables used in these models are explained in Table 1. Significance at the 1%, 5%, and 10% confidence levels is denoted with *** , **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variable	IPO	Trade sale	liquidation	IPO	Trade sale	liquidation	IPO	Trade sale	Liquidation
Amount	-0.005	0.003	-0.035**	-0.006	0.003	-0.044**	-0.007	0.003	-0.045**
Syndicat size	0.014	0.026**	0.102**	0.017	0.026**	0.129**	0.017	0.026**	0.128**
Age_oldest VC	0.008*	-0.002	-0.01	0.007	-0.001	-0.014	0.007*	-0.002	-0.013
Number of IPOs	-0.002**	-0.001**	0.001**	-0.002**	-0.001**	0.001**	-0.002**	-0.001**	0.002**
Low_high	-0.296**	-0.246**	-0.048	-0.089	-0.251**	-0.183	-0.415**	-0.243**	0.195
High_low	-0.148	-0.303**	-0.715*	-0.116	-0.277*	-0.372	-0.164	-0.326*	-1.067**
Low_low	0.387**	0.339**	0.031	0.395**	0.375**	0.215	0.434**	0.24**	-0.108
Low_high_internet				-0.611**	-0.025	0.636			
High_low_internet				-0.264	-0.23	-1.808*			
Low_low_internet				0.28	-0.308*	-0.933*			
Low_high_computer							0.326	-0.024	-0.501
High_low_computer							0.071	0.076	1.31
Low_low_computer							-0.062	0.298**	0.63
Fixed variables	Y	Y	Y	Y	Y	Y	Y	Y	
ln_ σ	0.442***	0.062**	0.640***	0.474***	0.026***	0.766***	0.471***	0.022**	0.795***
κ	-0.864***	-0.415***	-0.279	0.190***	0.455***	-0.541	-0.187***	-0.464***	-0.614
Observations	16450	16450	16450	16450	16450	16450	16450	16450	16450

Table 6. Dynamics in VC syndication and time to exit via IPO, trade sale, or liquidation.

Estimated coefficients for the competing risks model with time-varying covariates. The sample covers investment rounds for portfolio firms that received VC funding via a staged financing scheme. The dependent variable is *Duration*, which ends with an IPO, trade sale, or liquidation of a portfolio firm. *Duration* is defined as the number of days elapsed between the first VC round and either (i) the date of the VC exit from the portfolio firm or (ii) June 23, 2003, whichever is earlier. Columns 1-3 display estimated coefficients for the base model, which also controls for the *Fixed variables* including stage, industry, and the geographic location of the portfolio company and the VC firm, as well as the VCs' proximity to the portfolio company. Columns 4-6 additionally control for *Low_high_synd_internet*, which is the interaction between *Low_high_synd* and the *Internet* dummy variable. Columns 7-9 control instead for *Low_high_synd_computer*, which is the interaction between *Low_high_synd* and the *Computer* dummy variable. All the other variables used in these models are explained in Table 1. Significance at the 1%, 5%, and 10% confidence levels is denoted with *** , **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variable	IPO	Trade sale	Liquidation	IPO	Trade sale	Liquidation	IPO	Trade sale	Liquidation
Amount	-0.009**	0.001	-0.035**	-0.01**	-0.001	-0.041**	-0.009*	0.001	-0.034**
Syndicate size	0.026	0.037**	0.124**	0.027*	0.041**	0.148**	0.026	0.037**	0.123**
Age oldest VC	0.009*	-0.001	-0.009	0.009*	-0.001	-0.012	0.009*	0	-0.008
Number of IPOs	-0.002**	-0.001**	0.001**	-0.002**	-0.001**	0.002**	-0.002**	-0.001**	0.001**
Low_high_synd	-0.205**	-0.186**	-0.304	-0.157	-0.194**	-0.376*	-0.17*	-0.116	-0.228
Low_high_synd_internet				-0.414**	-0.167	-0.143			
Low_high_synd_computer							-0.131	-0.253**	-0.231
Fixed variables	Y	Y	Y	Y	Y	Y	Y	Y	
ln_ σ	0.463***	0.051	0.577***	0.466***	0.047	0.575***	460***	0.049	0.590***
κ	-0.798***	-0.269***	-0.139	-0.818***	-0.262**	-0.181	-0.778	-0.259**	-0.188
Observations	16450	16450	16450	16450	16450	16450	16450	16450	16450

$$\ln(t_k) = \alpha_0 + \alpha_1 Amount + \alpha_2 Syndicate\ size + \alpha_3 Age\ oldest\ VC + \alpha_4 Number\ of\ IPO + \rho_1 Lowhighsynd + \boldsymbol{\beta}\ Fixed\ variables + e \quad (3)$$

where, t_k is the variable *Duration* (as defined in Section 3) and *Amount, Syndicate size, Age oldest VC, Number of IPOs,* and *Low_high_synd* and *Fixed variables* as defined in Table 1.

Table 6 provides the estimation results from Eq. (3) for the *IPO*, *Trade sale* and *Liquidation* exit outcomes. Based on the parameter estimates of *Low_high_synd* shown in Columns 1-3, having more investors at the last financial round compared to the first financial round translated into about 20% and 19% quicker exits via IPO and trade sale, respectively. Column 4-9 further show that the link between increased syndication and successful exits is sensitive to the industry of the portfolio firm: for example, increased syndication at the last financial round accelerates the IPOs of internet firms by 41% but has no significant impact on their trade sale likelihood. In contrast, increased syndication at the last financial round accelerates the trade sale of computer firms by about 25% but has no significant impact on their IPO.

5. Conclusions

Our results indicate that compared to the fixed covariates framework, the time-varying covariates framework of competing risks model delivers more precise evidence on the impact of different funding characteristics on VC exit dynamics. Specifically, we show that optimal financing strategy is both industry- and exit-specific. While increasing financing over the course of investment duration is critical for accelerating the IPO exit of an internet company, alternative financing strategies yield almost similar hazards of IPO and trade sales exit outcomes for portfolio companies in the computer industry.

In contrast to previous findings our framework also provides evidence that an increase in the VC syndicate size does not always translate into quicker exits. Since we also control for the amount of capital invested at each financial round and market liquidity conditions in our model, the syndicate size of the corresponding financial round captures non-monetary value-adding (i.e., via better deal selection, or via greater complementarities of skills among syndicate partners), which according to our results appears critical for accelerating IPOs of single round investments but has no significant impact for companies receiving VC via multiple rounds. Our findings imply that syndication in a setting of staged financing may also be associated with some costs that if severe may totally absorb its value-adding benefits.

Finally, similar to the findings of Giot and Schwienbacher (2007), our analysis shows that when liquidity conditions improve, VCs rush to successful exits. However, the time varying covariates framework in contrast to the fixed covariates framework provides evidence that favorable market conditions delay write-offs. This may imply that when market conditions improve, VCs may purposefully postpone the liquidations of non-successful start-ups not to jeopardize the follow-up fundraising chances.

We outline several directions for future research. First, we acknowledge that the choice that VCs make between staged-financing and up-front financing while first investing in their portfolio firms may depend on the ex-ante risk content of these firms. To connect exit outcomes more accurately to the chosen funding strategy, further analysis is needed to consider for the possible selection in these two types of deals. Second, we recommend that future studies account for the possible endogeneity in funding profiles that may be a concern if the path taken by the capital invested in each round depends upon VCs beliefs regarding the future success prospects of a portfolio firm. We acknowledge that such an analysis is not straightforward in the time-varying covariates framework (Box-Steffensmeier and Jones, 2004).

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