The Leveraging of Silicon Valley*

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Abstract

Venture debt is now observed in 28-40% of venture financings. We model and document how this early-stage leveraging can affect firm outcomes. In our model, a venture capitalist maximizes firm value through financing. An equity-holding entrepreneur chooses how much risk to take, trading off the financial benefit against his preference for continuation. By extending the runway, utilizing venture debt can reduce dilution, thereby aligning the entrepreneur's incentives with the firm's. The resultant risk-taking increases firm value, but the leverage puts the startup at greater risk of failure. Empirically, we show that early-stage ventures take on venture debt when it is optimal to delay financing: such firms face higher potential dilution and exhibit lower pre-money valuations. Consistent with this notion, such firms take eighty-two fewer days between financing events. This strategy induces higher failure rates: $125,000 more venture debt predicts 6% higher closures. However, conditional on survival, venture debt-backed firms have 7-10% higher acquisition rates. Our study highlights the role of leverage in the risking-up of early-stage startup firms. Aggregation of these tradeoffs is important for understanding venture debt's role in the real economy.

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1 Introduction

Entrepreneurial ventures foster technological development, drive competition and create economic growth. However, entrepreneurs are usually liquidity-constrained, making the financing of entrepreneurial ventures through external capital an essential question in economics and finance. Although economic theory would generally predict that external debt is an unlikely vehicle for the financing of early-stage startups, the venture debt market has grown rapidly in recent years. Ibrahim (2010) estimates that venture lenders, including leader Silicon Valley Bank and specialized non-bank lenders, supply $1 - $5 billion to startups annually. In more recent work, Tykvová (2017) finds that around 28% of venture-backed companies in Dow Jones Venture Source utilize venture debt. In our large-sample analysis, we find that venture debt is often a complement to equity financing, with over 40% of all financing rounds including some amount of debt.[1]

One example is EValve Inc., a medical devices startup specializing in minimally-invasive cardiac valve repair technology. It raised a total of $117 million dollars in both equity and debt finance and was ultimately acquired by Abbott for $410 million in 2009. Shortly after raising $12 million dollars in a Series B equity round, EValve raised $4 million in venture debt from Western Technology Investments. Similarly, EValve raised a Series C round of $20 million dollars followed by a debt round of $10 million dollars (again from WTI).[2] When asked why the company took on debt, Ferolyn Powell, Evalve's president and CEO, argues that the benefit of delaying equity financing outweighed the costs. She says, "by allowing us to hit a critical milestone with that extra run time, even though drawing down the debt costs warrants and interest, our experience was that it paid for itself by increasing valuation and avoiding dilution."[3]

Venture debt is generally structured as a short-term (three-year) loan, with warrants for

[1] See Figure 1 for a breakdown of financing round by types. Ibrahim (2010) estimates that the venture debt market is approximately 10-20% of aggregate venture capital. The difference in magnitude is the syndication of rounds by both debt and equity investors.

[2] http://splitrock.com/2004/05/25/evalve-raises-20-million/

[3] https://www.wsgr.com/news/medicaldevice/pdf/venture-debt.pdf

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company stock. Its role differs from the now-ubiquitous convertible note contract (the standard early-stage seed financing contract), whose primary feature is its conversion to equity at a later stage. It also does not resemble traditional debt loans in that it is a debt instrument for venture equity-backed companies that lack collaterizable assets or cash flows. Instead, venture debt is secured (with uncertainty) by future rounds of equity finance. Proponents of venture debt and the nascent, important literature on venture debt (e.g., de Rassenfosse and Fischer (2016), Hochberg et al. ((forthcoming), González-Uribe and Mann (2017)) convincingly argue that it provides capital to extend the runway of a startup, allowing them to achieve the next milestone while minimizing equity dilution for both the founders and equity investors. However, this is inconsistent with Modigliani and Miller (1958), who show that the value of the firm should be unaffected by whether the firm is financed using debt or equity. Our model captures the intuition of avoiding dilution but deviates from M&M by introducing entrepreneurial action in the form of incentivizing risk-taking through the optimal use of debt. This mechanism is crucial because of the the impact to startups and the real economy from the fact that venture debt is still a debt product, which carries the traditional implications which arise when leveraging a firm.

In this paper, we provide theoretical foundations, supported by empirical evidence, on the use of venture debt. In the model, an entrepreneur trades off the financial benefits of risk-taking with the utility he forfeits if the firm fails. If the entrepreneur's equity is too diluted, he favors a low-risk (low-value) strategy. We show that venture debt can reduce dilution by delaying equity financing until a milestone is met and incents the entrepreneur to choose a high-risk (high-value) strategy. Empirically, we show that venture debt is utilized when expected dilution is high and when it is optimal to delay financing so that the next milestone may be reached. Furthermore, startups that take on venture debt have shorter time between financing events, higher failure rates, and higher acquisition rates conditional on survival.

The optimal use of early-stage leverage suggests several major changes in our perception of startups. First, if venture debt incents entrepreneurs and firms to "risk up", the innovation

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economy may be facing greater uncertainty (both financial and strategic) than in previous decades. Second, if venture debt increases expected firm value, more startups may be able to receive funding (ex-ante and interim) than would otherwise. Third, the use of venture debt may be changing the allocation of both human capital and startup finance capital toward the continuation of riskier endeavors and away from the alternative use of such resources.

To establish our theoretical predictions, we consider a three-date model. At date zero, a firm owns a risky asset of uncertain quality. At date one, the asset's quality is revealed after which the firm's strategy is chosen. At date two, the cash flow is realized.[4] Before each date, the firm must raise capital to avoid closure, e.g., to pay employees.

The firm is owned by an entrepreneur and a venture capitalist; both are risk-neutral.[5] The venture capitalist chooses how and when to raise capital to maximize the expected value of the firm.[6] In particular, at date zero, she has (1) the option of raising some portion of the required financing after the asset's quality is revealed and (2) access to both equity and venture debt investors. At date one, the entrepreneur implements the firm's going-to-market strategy, which is unobservable. Specifically, the firm's strategy determines the riskiness of the distribution of the terminal cash flow. The entrepreneur chooses how much risk to take, accounting for the value of his equity claim as well as the non-pecuniary utility he derives from continuation, i.e., the firm avoiding shutdown.

This non-pecuniary utility creates a wedge between the venture capitalist's and entrepreneur's incentives.[7] Unsurprisingly, when the entrepreneur's stake is excessively diluted, he chooses the low-risk (low-value) strategy. Preferring the high-risk strategy, the venture capitalist makes her financing decisions to minimize the likelihood this occurs. We show that if the firm's unconditional quality is sufficiently high, the firm can raise the required capital cheaply in one round

[4]Under the assumptions of the model, this terminal cash flow need not be realized and is equivalent to an expectation of the firm's value as a going concern.

[5]The venture capitalist is an equity investor from an earlier round.

[6]This is consistent with both the survey evidence from Ibrahim (2010) and Sage (2010).

[7]This wedge utilizes the well-documented fact that while both venture capitalists and entrepreneurs seek to maximize firm value, venture capitalists' often prefer higher volatility in their investments relative to entrepreneurs (who also value continuation of their startups).

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– the entrepreneur chooses the high-risk strategy and firm value is maximized. As unconditional quality falls, the entrepreneur's dilution increases; if it falls sufficiently, the entrepreneur chooses to scale back risk. In this case, the venture capitalist chooses to raise some portion of the needed funds after firm quality is known. We show that this is beneficial if the firm's asset is revealed to be high-quality: at that point, equity can be raised less expensively, reducing dilution (and potentially incenting the entrepreneur to take the high-risk strategy once more). On the other hand, it also creates the possibility of failure if the firm's asset is revealed to be low-quality.

Venture debt amplifies this effect. By borrowing today, the firm raises less equity at a low, unconditional value. This increases the required equity issued in the future, but this is done at a potentially high conditional value. Though it comes with increased risk of failure, we show that, in some cases, venture debt is strictly preferable from the venture capitalist's perspective.

The model generates several empirical predictions consistent with features of the venture debt market. First, all else equal, venture debt is more likely to be optimal when the entrepreneur faces high potential dilution - for instance, when the firm requires significant investments of capital. Second, we expect to see more venture debt when the benefits of risk-taking are low; such debt is necessary to incent the entrepreneur to choose the value-maximizing strategy. Third, we expect to see venture capital utilized by "mid-value" firms: those firm that firms can raise capital, but do so at great cost. Finally, we show that while the use of venture debt increases the short-term probability of firm closure it also increases the value of the firm, conditional on survival.

With these theoretical predictions in mind, we offer five, novel empirical contributions.

We begin by identifying which startups choose debt in their financing and how it. First, we show that potential dilution is a strong predictor of the decision to raise venture debt instead of venture equity. Indeed, startups with a standard deviation higher dilution from the current round are five percent more likely to issue such debt. Both entrepreneurs and investors value "skin-in-the-game" and the additional capital provided by a venture loan allows startups to

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achieve more progress before raising additional equity. Further, if the firm is able to reach its milestone (i.e., is "high quality" in the parlance of the model), this approach minimizes the dilution that occurs relative to securing such external capital at an earlier time.

We then provide evidence consistent with this intuition of venture debt as extending the runway. Our second contribution shows that firm quality realizations are a driver of venture capitalist preference for venture debt. We find that in early rounds, low pre-money valuations, which are indicative of missing milestones or targets, lead to an increase in the likelihood of raising debt.[8] Our third contribution finds that after early-stage startups choose venture debt, they return to the venture investor market in eighty-two fewer days, even after controlling for the amount of capital raised. This suggests that such firms are using venture debt as an extension (having failed to reach a needed milestone) and that they return to the market after more information is revealed about the firm's future prospects.

Turning to firm level outcomes, our fourth contribution shows that leverage makes the company more risky, at least until the next milestone is met. Specifically, debt increases the probability of startup closure in the first three years. An increase in early-stage financing to include $125,000 in venture debt is associated with a 6% higher likelihood of firm closing. As expected, firms which survive the risk generated by venture debt benefit. An early debt round increases the likelihood of exiting via acquisition, conditional on not closing, by 7-10%. This fifth contribution is consistent with the intuition that firms utilize venture debt not simply to prevent dilution but to improve firm value as well.

Our research adds to the current finance literature in several areas. First, this paper contributes to the growing literature on venture lending. The existing literature has focused on determinants of the lending decision. Hochberg et al. ((forthcoming) empirically tests the collateriability of patents as a driver of venture lending lending while de Rassenfosse and Fischer (2016) finds that backing from venture capitalists substitute for startups' cash flow in the lending decision. González-Uribe and Mann (2017) provides contract-level data on venture loans

[8]In later rounds, high pre-money valuations, which are indicative of stable returns, lead to an increase in traditional debt financing.

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and finds that intellectual capital and warrants are important features. These results corroborate the earlier market survey work by Ibrahim (2010) who finds that venture debt provides additional runway between early-stage rounds and are repaid through future equity raises. Similarly, his research also points to the importance of intellectual property as collateral for the loan. Missing from this, however, is a consideration of the risk implications of the leveraging of venture capital funded startups. Our paper instead studies the effects of the growth of the venture debt market on startup outcomes.

Secondly, our paper contributes to the broader literature on the financing of growth startups. Empirically, Kortum and Lerner (2000), Hirukawa and Ueda (2011), Nanda and Rhodes-Kropf (2013), and Kerr et al. (2014), show the effect of different types of equity-based venture capital on firm level outcomes. This paper, on the other hand, documents a different mechanism for accessing financial markets and thus, a different set of incentives for investors and entrepreneurs. On the theoretical side, our paper highlights a new channel through which staged financing, and in particular, venture debt, can be optimal. In contrast to the large literature which provides a role for staged financing (e.g., Bergemann and Hege (1998), Neher (1999), Casamatta (2003)), our model shows that firms may prefer staged financing in order to reduce dilution, aligning the entrepreneur's incentives with the firm.

The remainder of the paper is organized as follows. We describe the institutional details and provide a simple numerical example in 2. We present the model and develop testable empirical predictions in Section 3. Section 4 describes data sources and sample construction, while section 5 presents the main empirical results. Section 6 concludes the paper.

2 The Venture Debt Market

While debt has traditionally been an important source of external finance for companies, it did not gain prominence in the high-risk innovation economy until the 1970s. The lending industry began as equipment leasing, where leasing companies and banks would only provide

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collateralized loans for half the value of the equipment. As equipment financing became less important for startups, venture debt quickly evolved to loans for growth capital - capital that can be utilized for whatever purpose and is not tied to a specific asset. This shift is even more surprising given the lack of tangible collateral as security.

2.1 Venture Debt Loans

Venture debt differs from traditional debt in many ways. Venture debt loans are structured as short-term loans with repayment over 24-36 months. Loan sizes range between $1 million to $10 million with interest rates of 10-15%. Generally, there are 6 months of interest-only payments, followed by monthly payments of the principal and interest. Venture debt is also senior in the priority structure and thus, repaid first in the event of a bankruptcy or an exit. It is not equivalent to the ubiquitous convertible notes used in seed rounds. While loans may include warrants of approximately 5-15% of the loan size, the principal does not convert to equity at the next equity round.[9]

Importantly, venture debt is not dependent a startup having positive cash flows or substantial tangible assets and thus, not collateralized by assets.[10] According to Silicon Valley Bank (SVC), a technology-focused bank that is a large participant in the venture debt market, "neither approach works for startups that are pre-product or recently began generating revenue... Instead of focusing on historical cash flow or working capital assets as the source of repayment, Venture debt emphasizes the borrower's ability to raise additional capital to fund growth and repay the debt." This feature of the venture debt market is an important one to highlight. In an internal slide deck used by SVC, the primary repayment is defined to be cash flow from future equity while enterprise value is secondary.[11] Understandably, this has meant that venture debt is not exclusive to later-stage firms. Andy Hirsch, a lawyer specializing in corporate financing transactions, claims, "with those seed-stage and Series A companies, lenders look at the track

[9] Ibrahim (2010)provides survey evidence of the venture loan market and contract terms.

[10] While there exists work arguing that venture debt is collateralized by intellectual property in the form of patents or trade secrets, intangible assets are difficult to value and to foreclose on.

[11] See Figure 3 for SVC Osler slide deck.

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records of the VCs and assess the company's trajectory as to the likelihood that there's going to be a Series B; that's really what they are lending against in those cases."

A common timeline for venture debt looks like the following:

There is an initial round of equity financing, a round of debt financing, followed by another round of equity financing. In sum, venture debt are early-stage, non-collateralized, risky loans that are repaid through future equity issuances. The unique features of this market differentiate it from existing debt securities and necessitates deeper understanding.

2.2 Value to Investors

The majority of venture lenders in the United States can be classified into two groups: banks and speciality debt funds. The top banks participating in venture lending are Silicon Valley Bank, Square 1 Bank, and Bridge Bank. Investment banks and financial service companies like Goldman Sachs, Comerica Bank, and Wells Fargo have also moved into the space. Banks are subject to government regulation and have lower cost of capital. However, banks are also more likely to limit the size of loans, screen companies more strictly, and use financial covenants in order to mitigate risk.[12] In his interviews with industry experts, Ibrahim (2001) finds that banks interest rates are at prime plus 1-4% and the maximum loan size is $2 million. With the low interest rate, he attributes the bank's incentive to lend to being able to secure the startup's deposit accounts.[13] One of his interviewees claims that his bank makes "10% more off of deposit accounts than loans and fees."

In addition to banks, there are venture debt funds with major players such as Horizon Technology Finance, Lighter Capital, Trinity Capital Investment, and Western Technology Investment. Debt funds are structured similarly to venture capital funds. They raise capital from limited partners such as institutional investors, endowments, and wealthy individuals. Debt funds charge higher interest rates, in the ballpark of 10-15%, and are unlikely to implement

[12]Banks would often have subjective default clauses, such as Material Adverse Change (MAC), that allow them to call their capital back.

[13]This is in line with the relationship banking literature.

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financial covenants. Although the higher interest rate provides one motivation for fund lenders, another is the short-term nature of the loan. The quick repayment allows for "multiple shots on goal" through the re-deployment of capital in the first four years of a fund's 10-year life.[14] Moreover, as noted above, venture lenders do select investments based on the involvement of a venture capitalist. Therefore, providing loans to startups after initial VC equity financing could have a lower default risk than commonly believed.

2.3 Value to Startups

The most commonly cited role for venture debt is to extend the cash "runway" of a startup and minimize equity dilution.[15] To understand this effect, it is important to note that venture capital valuation is typically based on achieving milestones. Series A, B, C, etc refers to both the round of financing as well as the development stage of the startup. As the startup achieves major milestones such as product development or revenue growth, it is rewarded with an increase in valuation. This implies that raising outside capital immediately following a milestone leads to the least amount of equity dilution.

The milestone-framework for valuation provides an incentive for startups to delay equity rounds through the use of venture debt. Because there is uncertainty, by extending the cash runway, startups can achieve the next milestone or provide insurance for potential delays. According to Stephen Levin from Leader Ventures, "such milestones are important in venture debt because they serve as the basis for a relationship that lenders ideally look for as providing identifiable targets that can be achieved using debt."

In the later stages, venture debt can provide the bridge to positive cash flows, eliminating the need for an additional round of equity of financing altogether.

[14] WTI case

[15] Equity dilution is a reduction in ownership for a share of stock caused by the issuance of new shares. The amount of equity given up in each round is the investment amount divided by the company valuation in the round. The amount of dilution is defined to be the prior ownership percentage times the equity percentage issued. This is in contrast with dilution in loss of value in adverse selection models.

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3 Model

3.1 Overview and Graphical Example

A widely held belief in industry is that startups use venture debt in order to avoid dilution from equity issuances, especially when the firm needs to extend the runway to reach a milestone. However, under the seminal theory of Modigliani and Miller, the value of the firm should be unaffected by whether the firm is financed by debt or equity. Furthermore, under these same assumptions, it is straightforward to show that issuance timing should also be irrelevant for the expected value of the firm.

What is missing from the practitioner's interpretation of dilution driving the rise in venture debt is the role of entrepreneurial action. The deviation from M&M caused by entrepreneurial action allows us to capture the timing and patterns of issuances we see in the startup market.

An entrepreneur wants to maximize the value of his equity claim as well as the non-pecuniary utility he derives from startup continuation. The entrepreneur has control over firm strategy, and his preference for continuation creates a misalignment with the venture capitalist, who always prefers high-risk strategies. Because the VC controls the financing decisions (due term sheet contracts), the VC can optimally use debt to induce more entrepreneurial risk-taking. In addition, the VC's use of debt increases the entrepreneur's "skin-in-the-game" which further incentivizes the entrepreneur to choose high-risk actions.[16] This results in higher firm value coming at the expense of a higher probability of failure.

We provide a simplified illustration highlighting the use of venture debt on firm outcomes in Figure 4. In this example, the startup raises a small amount of capital in a seed round in order to fund the development of a minimally viable product. The startup expects that this capital will last for two years, and they will be able to achieve the proof of product milestone prior to raising a Series A round. However, the development runs into a few hiccups, and it is now expected to take another year. This is shown as the cash shortfall point in the figure. The

[16] This is a novel channel that is different than the traditional role of levered equity.

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cash-strapped company can either raise a Series A round at a lower valuation than expected (Panel A) or shut down if unable to raise capital (Panel B).

Alternatively, with the introduction of venture debt in the entrepreneurial finance market, the startup can raise a small amount of debt to "extend the runway". In Panel C, the startup reaches the cash shortfall point and raises enough debt to reach the proof of product milestone. After reaching the milestone, the startup will now raise the Series A round. This time, the investment amount will be higher (due to the additional amount needed to repay the debt), but the valuation will also be much higher. The higher valuation comes from debt incentivizing higher entrepreneurial risk-taking. On the other hand, while the debt buys the firm more time to reach the milestone, the additional risk could lead to more failures (Panel D). What is not obvious in the graphs, but we show in the following sections, is that the probability of ending up in Panel D is larger than the probability of ending up in Panel B.

3.2 Model setup

There are three dates, $t \in \{0, 1, 2\}$. A firm owns a risky asset which pays a cash flow γY at the end of date two. At the start of each date, the firm must raise X_t (to pay employees and to produce goods) from outside investors.[17] If it fails to do so, the firm shuts down, i.e. $Y = 0$; otherwise, $Y > 0$ is constant. γ can be interpreted in many ways in our model, including a pricing multiple (e.g. price-to-sales), the fraction of the market obtained by the firm, even the likelihood the firm is able to successfully exit. The asset is initially of unknown quality. If the initial investment (X_0) is made, the quality of the asset is revealed. If the intermediate investment (X_1) is made, the firm can choose its going-to-market strategy, which determines the distribution of γ. Prior to the terminal investment (X_2),γ is realized.[18]

The firm is initially owned by (i) a risk-neutral entrepreneur and (ii) a risk-neutral venture capitalist, who invested prior to date 0. The firm has no debt outstanding, and the venture

[17]The entrepreneur cannot self-finance: he has no wealth or outside labor income. Future equity capital could also come from the inside venture capitalist, described below, but for ease of exposition, we focus on this setting.

[18]This is consistent with the example above, where γ is realized after the startup chooses the product development strategy but before the terminal investment X_2 is raised.

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capitalist owns a fraction θ of the firm's equity. The price of each claim is set such that outside investors breakeven in expectation, conditional on the information available on that date.[19]

The initial venture capitalist is responsible for all financing decisions due to the control exerted by the term sheet. At each date, her objective is to maximize the expected payoff from her equity claim. Any equity issued by the firm is dilutive (of all existing owners), and we denote the fraction of the firm sold at each date by α_t. The firm can issue one-period straight debt (with face value F) at date zero.[20] The firm generates no cash flows but this venture debt is backed by the promise of equity issuance in the next period. If the firm is unable to raise the capital required and repay the debt owed at date one, the firm closes.[21]

At dates one and two, the venture capitalist raises the required capital as long as it is feasible. At date zero, the VC must first decide whether she to (i) raise $X_0 + X_1$ (which we will call "upfront" financing) or (ii) to raise only X_0 and delay the financing of X_1 until after the firm's milestone is (potentially) reached, i.e. the firm's quality is revealed. We will call this latter option "staged" financing. If the venture capitalist chooses staged financing, she must also choose what fraction of the initial capital to raise in equity vs. debt.[22]

The entrepreneur is responsible for choosing the firm's strategy τ, which is unobservable and thus non-contractable.[23] τ, where $\tau \in [0, \tau_h]$, captures the riskiness of the firm's strategy.[24] For tractability, we assume:

[19]This is equivalent to assuming (i) competitive capital markets and (ii) a perfectly elastic supply of the risk-free asset.

[20]It is without loss of generality to assume that any capital raised at date two is via equity.

[21]This assumption is not necessary but is made for tractability - the intuition for our results holds as long as there is some liquidation cost in bankruptcy.

[22]We assume that the firm cannot repurchase equity at date zero ($F \leq X_0$).

[23]We take as given that the entrepreneur cannot be relieved of her role – for instance, he may possess unique human capital, specific to the firm's asset.

[24]An increase in τ is a mean-preserving spread with respect to the distribution of γ. On the other hand, as we detail below, such risk-taking (weakly) increases the expected value of the firm.

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$$\gamma \quad = \quad \begin{cases} \tilde{\gamma} + \delta & \text{with probability } \tau \\ \tilde{\gamma} & \text{with probability } p_1 - 2\tau \\ \tilde{\gamma} - \delta & \text{with probability } (1 - p_1) + \tau \end{cases} . \tag{1}$$

p_1 is defined to be the quality of the firm; as p_1 increases, the expected firm value increases through γ. Hereafter, we refer to τ as risk-taking. δ is a constant that is known to all players and increases the upside benefits of risk-taking.

We assume that the entrepreneur receives non-pecuniary utility over continuation, i.e., if $Y > 0$. We model this simply, so that the entrepreneur chooses τ to maximize

$$A_1 \mathbb{E}\left[(1 - \alpha_2)\, \gamma Y \,|\, p_1, \tau\right] + b\mathbb{P}\left[Y > 0 | \, p_1, \tau\right]. \tag{2}$$

where $A_1 \equiv (1 - \theta) \prod_{j=0}^{1} (1 - \alpha_j)$ is the entrepreneur's current stake in the firm and $b > 0$ parameterizes the level of continuation utility relative to his financial gains. This non-pecuniary utility is a source of potential misalignment between the entrepreneur and the venture capitalist's incentives. Thus, the venture capitalist uses her financing decision to influence the action taken by the entrepreneur.

Finally, we assume that firm quality is binary: with probability q the asset is high-quality ($p_1 = p_h$), otherwise it is low-quality ($p_1 = p_l < p_h$).[25] The ex-ante quality of firm at time 0 is $p_0 \equiv q p_h + (1 - q)\, p_l$.

3.3 Optimal Issuance Policy

We work recursively through the optimal issuance policy, assuming that the firm was able to successfully finance the previous investments.

[25] To ensure that all probabilities are non-negative, let $\tau_h < \frac{p_l}{2}$.

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3.3.1 Date Two: Payoffs

In order to raise sufficient capital to finance firm operations, the firm must sell a fraction,

$$\alpha_2 = \frac{X_2}{\gamma Y}, \tag{3}$$

of the firm's equity. In order for this to be feasible ($\alpha_2 \leq 1$), it must be the case that

$$\gamma \geq \underline{\gamma} \equiv \frac{X_2}{Y}. \tag{4}$$

$\underline{\gamma}$ denotes the final milestone (e.g. scaling and revenue growth) the firm needs to achieve in order to successfully raise capital and exit the firm at the terminal value, γY.

3.3.2 Date One: Optimal Entrepreneurial Strategy

Knowing that his claim is worthless unless $\gamma \geq \underline{\gamma}$, the entrepreneur chooses the firm's strategy τ to maximize

$$\max_{\tau \in [0, \tau_h]} A\mathbb{E}\left[(1-\alpha_2)\,\gamma Y \,|\, p_1, \tau\right] - b\mathbb{P}\left[\gamma \geq \underline{\gamma} | \, p_1, \tau\right]. \tag{5}$$

To highlight how venture debt affects the firm's strategy, we assume that $\tilde{\gamma} - \delta < \underline{\gamma} < \tilde{\gamma}$.[26]

We document that the entrepreneur's choice of risk-taking (τ) has two effects. First, risk-taking increases the probability of firm closure, $\mathbb{P}\left[\gamma \geq \underline{\gamma} | \, p_1, \tau\right] = p_1 - \tau$. Second, risk-taking increases the expected value of the entrepreneur's equity stake, as given by:

$$\mathbb{E}\left[(1-\alpha_2)\,\gamma Y \,|\, p_1, \tau\right] = \mathbb{P}\left[\gamma \geq \underline{\gamma} | \, p_1, \tau\right] \mathbb{E}\left[(1-\alpha_2)\,\gamma Y \,|\, p_1, \tau, \, \gamma \geq \tilde{\gamma}\right] \tag{6}$$

$$= p_1\left[\tilde{\gamma} Y - X_2\right] + \tau \left[\underbrace{\delta Y - (\tilde{\gamma} Y - X_2)}_{>0}\right]. \tag{7}$$

[26] If $\tilde{\gamma} - \delta \geq \underline{\gamma}$, then the manager is indifferent with respect to the choice of τ: the expected value of her claim is constant and she faces no risk of failure. Similarly, if $\tilde{\gamma} < \underline{\gamma}$, then the manager always chooses to maximize the firm's riskiness: both firm value and the probability of success are strictly increasing in τ.

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Risk-taking increases the expected value of equity because although the probability of closures increases with risk, it is outweighed by the increase in the value of equity, conditional on survival.[27] This does not mean that the entrepreneur always takes the high-risk action because this comes at a non-pecuniary cost to himself through the level of continuation utility. This intuition is stated in the following lemma.

Lemma 1. *Let $\tau(A_1)$ be the entrepreneur's optimal choice of risk. The entrepreneur chooses the riskiest strategy ($\tau(A_1) = \tau_h$) if and only if*

$$A_1 \geq \frac{b}{\delta Y - (\tilde{\gamma} Y - X_2)} \equiv \bar{b}. \tag{8}$$

Otherwise, he optimally sets $\tau(A_1) = 0$.

The entrepreneur faces a tradeoff and is willing to risk up, i.e., set $\tau = \tau_h$ if and only if he has sufficient "skin-in-the-game". Note that the entrepreneur's cutoff for choosing which strategy to take ($\bar{b}$) does not directly depend upon whether the firm is high (p_1^h) or low (p_1^l) intrinsic quality. However, if the firm chooses to utilize venture debt (or more generally, delay financing), whether the entrepreneur is above or below the cutoff will be determined by the realization of intrinsic quality through its impact on dilution.

From the venture capitalist's perspective, risk-taking is always valuable, as she suffers no non-pecuniary disutility if the firm closes.

3.3.3 Date One: Optimal Issuance Policy

If the firm has already raised the capital necessary for investment (X_1) as part of the initial round of financing, there is no issuance decision to be made and no further dilution occurs ($\alpha_1 = 0$). Let A_1^0 denote the entrepreneur's stake when there is upfront financing. We note that learning the quality of the firm at date one does not alter the entrepreneur's stake (A_1^0).

[27] The value of equity is convex in γ - as a result, a mean-preserving spread over the distribution of γ increases the expected value of equity.

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Then, by Lemma 1, if the firm is financed upfront, the entrepreneur either (i) always takes risk ($A_1^0 \geq \bar{b}$) or (ii) never takes risk ($A_1^0 < \bar{b}$).

On the other hand, conditional on having raised just X_0, the venture capitalist must now raise enough capital to make (i) the additional investment (X_1) as well as (ii) sufficient funds to repay the venture debt (if any) issued at date zero.[28] Thus,

$$\alpha_1(p_1) = \frac{X_1 + F}{\mathbb{E}\left[(1-\alpha_2)\gamma Y \,|\, p_1, \tau\left(A_1(p_1)\right)\right]} \tag{9}$$

where F is the face value of venture debt issued at date zero. Investors, knowing that the size of the entrepreneur's stake affects how much risk he takes, account for this when valuing their investment in the firm. As the required financing needs ($X_1 + F$) grow, so must the fraction of the firm sold to new investors. This decreases the entrepreneur's stake, A_1. Since the size of the entrepreneur's stake (A_1) is increasing in the quality of the firm, p_1, this intuition creates a clear link between firm quality and firm strategy, as summarized in the lemma below.

Lemma 2. *There exists a threshold of intrinsic quality, p_e, such that if $p_1 \geq p_e$, the entrepreneur picks the high-risk strategy, i.e. $\tau(A_1(p_1)) = \tau_h$; otherwise, he opts for the low-risk strategy, i.e., $\tau(A_1(p_1)) = 0$.*

Thus, the realized quality of the firm can alter the firm's strategy (and therefore, its expected value).

In order for the firm to successfully raise capital at date one, it must be the case that $\alpha_1(p_1) \leq 1$. If this threshold were reached, the entrepreneur would be fully diluted and so chooses the low-risk strategy, implying that[29]

$$p_1 \geq \frac{X_1 + F}{[\tilde{\gamma} Y - X_2]} \equiv \overline{p} \tag{10}$$

As at date two, this should be interpreted as a milestone the firm must reach in order to

[28] Recall that debt is not available at date one.

[29] In order for the entrepreneur to choose the risky strategy he must still own some fraction of the firm's equity.

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successfully issue equity at date one. Equation (10) highlights one potential cost of debt - its issuance at date zero may preclude the entrepreneur from receiving financing at date one.[30]

3.3.4 Date Zero: Staging

If the venture capitalist chooses upfront financing, then investors breakeven in expectation if

$$\alpha_0 = \frac{X_0 + X_1}{\mathbb{E}\left[(1-\alpha_2)\,\gamma Y || \alpha_0\right]}. \tag{11}$$

Then, with upfront financing, the entrepreneur chooses the risky strategy (regardless of asset quality) as long as $A_0^1 = (1-\theta)(1-\alpha_0) \geq \bar{b}$, and the firm is able to obtain upfront financing as long as $\alpha_0 \leq 1$, i.e.

$$\frac{X_0 + X_1}{p_0\left[\tilde{\gamma} Y - X_2\right]} \leq 1 \tag{12}$$

To make clear our theoretical predictions, we will make use of this observation and utilize the following definitions:

- A **low-value** firm cannot obtain upfront financing.
- A **mid-value** firm can obtain upfront financing but pursues the low-risk strategy.
- A **high-value** firm can obtain upfront financing and pursues the high-risk strategy.

Proposition 1. *A high-value firm raises the capital required to reach the next stage in one round, i.e., utilizes upfront financing.*

The occurrence of upfront financing is rarely seen in practice. In the startup world, the probability of success is rarely sufficiently high to raise all capital upfront. However, our results

[30] Finally, as we show in the proof of Lemma 2, it is not necessarily the case that $p_e \geq \overline{p}$: engaging in the risky strategy may be necessary to secure financing (due to the increase in expected value the risky strategy generates).

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on the staging of capital is key to understand how the majority of startups in the innovation economy are financed and how the timing of financing affects entrepreneurial decision-making.

Proposition 2. *A low-value firm always prefers staged financing. A mid-value firm prefers to utilize staged financing as long as*
(1) capital can be raised when the asset is revealed to be low-quality ($p_l \geq \bar{p}$) or
(2) the high-quality asset is sufficiently valuable ($p_h \geq \underline{p_h}$) and the low-quality asset is not too valuable ($p_l \leq \overline{p_l}$), where $\underline{p_h}$, $\overline{p_l}$ are defined in the proof.

Suppose the entrepreneur chooses the low-risk strategy with upfront financing – the firm is mid-value. Then, as argued above, the entrepreneur whose asset is revealed to be low-quality will do the same with staged financing. But what happens if the asset is revealed to be high-quality? In this case, staged financing *reduces dilution* relative to upfront financing — investors are willing to pay more for any equity issued when they know the asset is high-quality. If the information revealed about the asset is good (i.e., if $p_h \geq p_e$), the entrepreneur will choose the high-risk strategy, making staged financing strictly preferable. Moreover, if the information revealed about the asset is sufficiently good (i.e., if $p_h \geq \underline{p_h}$) and the value of financing a low-quality asset isn't too high (i.e., if $p_l \leq \overline{p_l}$), then the venture capitalist will choose staged financing even if the firm must shut down once the asset is revealed to be low-quality.

Finally, with a low-value firm, the venture capitalist cannot obtain upfront financing – the firm's unconditional value is negative. Of course, with staged financing, the firm will also surely shut down at date one if the asset is revealed to be low-quality. On the other hand, investing in a firm revealed to be high-quality can be profitable at date one. Knowing this, investors at date zero may finance the firm in the hopes that this comes to pass. Even with a low-value firm, it is possible that the entrepreneur will choose the high-risk strategy when date one financing is extended; in fact, such financing may only be feasible when this choice is made (when $\overline{p} \geq p_e$, as discussed above).

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3.3.5 Date Zero: Venture Debt

Proposition 3. *If the firm can obtain financing at date one, a mid-value firm prefers venture debt, sometimes strictly.*

The value of staged financing is that it can reduce dilution when the asset is revealed to be high-quality. In our setting, venture debt amplifies this effect. By borrowing at date zero, the firm raises (1) less equity when the firm is valued unconditionally (date zero) and (2) more equity when the firm is revealed to be high quality (date one). As the proposition makes clear, in some cases this amplification is necessary: relying on equity only can leave the entrepreneur with too little incentive to take risk. As the proof of proposition 3 argues, venture debt is more likely to be necessary at such a mid-value firm when

1. required investment (X_0, X_1) and initial dilution ($1 - \theta$) increase, and

2. gains from risk-taking (δ, τ_h) and unconditional asset quality (p_0) decrease.

All else equal, such changes make it more likely that the entrepreneur will choose the low-risk strategy, making venture debt a valuable antidote. We end this section by summarizing the implications of venture debt for firm outcomes.

Corollary 1. *The optimal use of venture debt*

(1) increases the expected value of the firm,

(2) increases the probability of short-term failure,

(2) increases the firm's expected value, conditional on survival, and

(3) decreases the firm's dilution if the asset is revealed to be high-quality.

With these predictions in mind, we turn now to a description of the data analyzed.

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4 Data and Descriptive Findings

Our data is collected from CrunchBase, a crowd-sourced database that tracks start-ups.[31] CrunchBase, which investors and analysts alike consider the most comprehensive dataset of early-stage start-up activity, describes itself as "the leading platform to discover innovative companies and the people behind them." CrunchBase was founded in 2005 but include backfill data from the mid-1900s. To address concerns of backfill bias, we limit the sample from 2000 onwards.

The start-up firm characteristics of interest from CrunchBase include: the entrepreneur(s), high-leveled employees, founding date, current status (ongoing, inactive), and exit outcomes (IPO, acquired, closed). We also have round level data on each financing event. The round level characteristics include: date of closing, investors name and type (debt, equity, angel, etc.), investment amount, and stage of financing (Series A, B, C, D). For a subset of the rounds, we also have data on pre-money valuations.

CrunchBase has many advantages over traditional finance databases such as VentureOne. One distinct benefit necessary in our context is that CrunchBase collects and aggregates all relevant startup data from the greater Web. If a startup receives Bloomberg press coverage regarding a C-suite employee change, CrunchBase will incorporate this information automatically. Additionally, CrunchBase will timestamp the event. Given that many startups rarely (and potentially endogenously) self-report closures, this provides us with a way to distinguish inactive firms from ongoing firms. We classify any firm that has no "updates" within the last two years as inactive.

The second benefit that is useful for our analysis is the availability of detailed investor information. Many financing rounds are syndicated, meaning the round has more than one investor. While CrunchBase classifies these syndicated rounds as venture, this greatly understates the use of venture debt in early-stage financing. In addition to classifying rounds as fully debt,

[31] https://www.crunchbase.com/#/home/index and http://techcrunch.com/ CrunchBase. For more information on the use of this dataset, refer to Wang (2017).

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fully equity, we also separately identify syndicated debt rounds. Syndicated debt rounds are rounds that has both debt and equity financing. The limitation of our data is that we do not have contract-level data on the loans meaning we don't have information on the interest rates or associated warrants. However, we take comfort in knowing that the contracts of venture loans are relatively standard across firms.[32]

The main dataset includes 62,403 firms and 135,069 financing rounds during the period 2000-2017. Table 1 presents the company-level summary statistics.[33] A startup in our sample has on average two rounds of financing, with the first round occurring approximately three year after startup founding and 36% of all rounds involving some debt financing. We distinguish between early and late debt with early debt defined as a debt round that occurs prior to Series B financing. The total amount of investment received during a startups lifetime is $14.5 million of which $2.3 million is from early debt rounds. Consistent with industry-level estimates of exit rates, 7% of resolved startups go through an initial public offering (IPO), 34% are acquired, and 59% of the firms are closed/inactive.

Table 2 presents the round-level summary statistics broken down by Series. The Series show in the different panels is the actual round (for equity rounds or equity-debt syndicate rounds) or the would-be round for debt financing had the firm issued a equity round. Dilution is the reduction of ownership in the company as measured by the ownership percentage of the new investor in the current round. The pre-money valuation, which is sparsely reported in CrunchBase, is the valuation accruing to founders and prior investors as implied by the valuation of the current investment. Burn Rate Duration is the number of days forward until the next financing.

[32] Cite needed.

[33] All tables are found in the Appendix.

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5 Empirical Analysis

First, we examine the decision of a startup to take on venture debt. Proposition 3 of the model states that the firm is more likely to issue venture debt if

1. the entrepreneur's dilution increases,

2. the unconditional value of the firm decreases, and

3. the required capital until the milestone is met decreases holding the total investment $(X_0 + X_1)$ fixed.

In table 3, we present the results of a logit regression and the marginal effects of the round-level characteristics on the choice of debt versus equity. Each column subsamples only to estimate rounds for Series A, Series B, or Series C/D in order to both control for a startup's milestones and to show how the coefficients change across a startup's lifecycle. The series letter is the actual round for equity rounds and the would-be rounds for debt financing had the firm issued an equity round. Our main variable of interest is cumulative entrepreneurial dilution as measured by the total reduction in the entrepreneur's ownership percentage of the company. For a given round of financing, round level equity dilution is defined to be:

$$Dilution_t = \frac{Investment_t}{PostMoneyValuation_t}$$

We assume that the new shares issued dilute all prior investors on a pro-rata basis implying that the entrepreneur's cumulative dilution after round t is:

$$CumulativeDilution_t = Dilution_t * (1 - Dilution_{t-1}) + Dilution_{t-1}$$

In column 1, we find that the decision to take on debt does increases as dilution increases just as the model predicts. A one standard deviation increase in dilution in the seed/series A round leads to a 7% increase in the likelihood of issuing debt. This effect represents a 27%

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increase in percentage change. A one standard deviation increase in dilution leads to a 2.13% increase in the likelihood of issuing debt in a Series B round. The effect diminishes in both economic and statistical magnitude as the startup moves further along in financing rounds. For robustness, we also re-run specifications using an alternate definition of dilution (current round investment divided by cumulative investment) and find similar results. These results suggest that in earlier rounds, when uncertainty is higher, the inability to reach certain milestones leads to the issuance of venture debt. On the other hand, the benefits of venture debt is lower in later stages when the startup has more consistent cash flows.

Next, we evaluate the effect of firm quality on the likelihood of issuing debt versus equity in Table 4. We separate the sample based on debt only rounds and syndicated debt and equity rounds. Again, we subsample by Series to control for baseline quality and survival. In column 1, we present results from a multinomial logit specification where the omitted category is raising an equity-only round. The dependent variable is the choice of venture debt or syndicated debt and equity. The coefficient of interest is a dummy variable for having a low value gain relative to the previous round. Specifically, value gain is measured as the difference between the current round's pre-money valuation and the post-money valuation of the prior round. Focusing on the debt only rounds, we find consistent positive and statistically significant coefficients on low quintile value gain. Firms that do not perform as expected (low valuation gains) in between financing rounds are more likely to issue debt compared to equity. While we do not find that *dilution* has an impact, we note that companies with low value gains are exactly the ones experiencing higher dilution due to the increased cost of equity. The results flip for syndicated debt and equity rounds. In particular, companies that have low value gain are less likely to issue both debt and equity relative to equity only.

In table 5, we test the final prediction of Proposition 3: the lower the required capital x_0 until the milestone, the higher the likelihood of debt issuance holding the total investment $(x_0 + x_1)$ fixed. The empirical specification we study is the effect of debt on burn rate, defined as the realized time (forward looking) before the firm raises the next round. We control for the amount

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of current investment since a higher investment amount should by definition provide a longer runway for the firm. We choose this specification because of the following intuition. Suppose a startup need to raise a fixed amount of capital in the next couple of years for research and development. The sooner information is revealed, the less money the startup needs to raise at the unconditional expensive price, and the more money it can raise at the cheap post-milestone price. This is exactly when venture debt is most valuable. Thus, forward-looking duration is proxying for this "sooner revelation of information" or "reaching the milestone". Put differently, debt is extending the runway of a firm by providing capital when the milestone has not been reached. We find that debt decreases the duration until the next round, consistent the model's intuition.

Next, we focus our attention on corollary 1 of the model, the effect of venture debt on firm-level outcomes. The optimal use of venture debt

1. increases the probability of failure,

2. increases the firm's expected value, conditional on survival, and

3. decreases the firm's expected dilution if the asset is revealed to be high-quality.

In table 6, we focus on the likelihood of firm-level closing as a function of the total debt financing round investment dollars. The dependent variable is an indicator for the startup closing. The estimation is logit, reporting the marginal effects effect for a change in the probability of closing. The variables of interest are the total money raised by the startup (Log Total Investment) and the total money raised in a debt or debt syndicated round (Log Debt Investment). In column 1, the coefficient on Log Total Investment is negative and statistically significant at the 1% level. Consistent with our intuition, this implies that raising more capital leads to a lower probability of startup failure on average. The coefficient on Log Debt Investment is also negative and statistically significant, suggesting that debt extends the runway, thus delaying creative destruction in preference for risk. In column 2, we disaggregate debt investment into debt investment before and after Series B. Interestingly, the coefficient on Log Debt Investment

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remains negative and statistically significant, but the coefficient on Log Debt Investment Prior to Series B is positive and significant. A 10% increase in the amount of early-stage debt investment increases the probability of closure by 6.5%. While the optimal use of debt increases the firms' expected value and extends the runway, it also increases the probability of failure. Venture debt provides a lever for the VC to induce risk-taking.

In order to disentangle the heterogenous effects of early vs. late debt, we turn to a hazard model of closures in table 7. Survival models such as the cox proportional hazard model relate the time that passes before closure to the covariates that may be associated with that quantity of time. Each observation here is a round-year. We essentially line up the treatment of companies with taking on either debt or equity at a particular time and look forward as if a medical trial -- using only ex-ante observables in the estimation. We force within-bucket analysis based on prior investments, round series, lag premoney valuation. The caveat is that we cannot fully assert that we have removed all selection but we think that at a minimum, our outcome effects allow us to speak to the mechanisms of the model. The reported coefficients are the hazard ratios. In the first column, the coefficient tells us that going from equity to debt in the seed and Series A rounds increases the probability of failure in any given year by a factor of 1.109 meaning that companies that take on debt have a 10.9% higher hazard risk than companies that take on equity.

In table 8, we show the effect of debt on positive exit outcomes (IPO, Acquisition), conditional on survival. The estimation is a cox proportional hazard model, and the independent variable of interest, Debt Round, is the choice of venture debt versus venture equity for each round. We also control for the current opportunity set by controlling for the log of the money raised in the current investment round. We include the same fixed effects as the prior specification. Across all series, we find that firms that take on debt are consistently more likely to be acquired than firms that take on equity. A firm that chooses debt over equity in the Series A round increases the probability of being acquired in any given year by a factor of 2.184.

In sum, our empirical results indicate that the startup landscape is fundamentally altered

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by the introduction of venture debt. Firms that take on leverage experience more downside (closures) along with more upside (acquisitions).

6 Conclusions

Our results demonstrate that the introduction of venture debt has potentially dramatic implications for early-stage firms. While such issuance may increase firm value and allow firms to obtain otherwise unavailable financing, it can carry with it significantly more risk, both strategic and financial. We find empirical evidence consistent with our theoretical predictions and, in particular, the role venture debt plays in extending the firm's runway. Given the recent growth in the venture debt market, and its prevalence across the innovation economy, we hope to build on this research to study its implications for the real economy.

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A Proofs

1

Proof of Lemma 1

1

First, we confirm (6): 1

$$\mathbb{E}\left[(1-\alpha_2)\,\gamma Y \,|\, p_1, \tau\right] = \tau\left[\left(1-\frac{X_2}{(\tilde{\gamma}+\delta)\,Y}\right)(\tilde{\gamma}+\delta)\,Y\right] \tag{13}$$

$$+\,(p_1-2\tau)\left[\left(1-\frac{X_2}{(\tilde{\gamma})\,Y}\right)(\tilde{\gamma})\,Y\right] \tag{14}$$

$$= p_1\left[\tilde{\gamma}Y - X_2\right] + \tau\left[\delta Y - (\tilde{\gamma}Y - X_2)\right] \tag{15}$$

1, 1, 6, 9

Note that the last term in brackets is positive as long as

$$\delta Y > (\tilde{\gamma}Y - X_2) \tag{16}$$

$$\frac{X_2}{Y} > \tilde{\gamma} - \delta \tag{17}$$

1

which is true by assumption - the firm cannot get financing at date two if $\gamma = \tilde{\gamma} - \delta$. Rewriting the entrepreneur's objective function yields 1

$$A_1\left(p_1\left[\tilde{\gamma}Y - X_2\right] + \tau\left[\delta Y - (\tilde{\gamma}Y - X_2)\right]\right) + b\,(p_1 - \tau) \tag{18}$$

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1

This is linear in τ, implying a corner solution: $\tau* \in \{0, \tau_h\}$. The entrepreneur's utility is weakly increasing in τ as long as 1

$$A_1 \left[\delta Y - (\tilde{\gamma} Y - X_2)\right] - b \geq 0 \tag{19}$$

which completes our proof. □ 1

Proof of Lemma 2

1

Rewriting (8), the entrepreneur chooses the risky strategy as long as

$$\alpha_1(p_1) \leq 1 - \left[\frac{\bar{b}}{(1-\alpha_0)(1-\theta)}\right] \tag{20}$$

$$\frac{X_1 + F}{1 - \left[\frac{\bar{b}}{(1-\alpha_0)(1-\theta)}\right]} \leq \mathbb{E}\left[(1-\alpha_2)\gamma Y \,|\, p_1, \tau\left(A_1\left(p_1\right)\right)\right] \tag{21}$$

$$\frac{\frac{X_1+F}{1-\left[\frac{\bar{b}}{(1-\alpha_0)(1-\theta)}\right]} - \tau_h\left[\delta Y - (\tilde{\gamma} Y - X_2)\right]}{\left[\tilde{\gamma} Y - X_2\right]} \equiv p_e \leq p_1 \tag{22}$$

6

This threshold exceeds $\bar{p}$ as long as 1

$$\frac{X_1 + F}{\left[\tilde{\gamma} Y - X_2\right]} \leq \frac{\frac{X_1+F}{1-\left[\frac{\bar{b}}{(1-\alpha_0)(1-\theta)}\right]} - \tau\left[\delta Y - (\tilde{\gamma} Y - X_2)\right]}{\left[\tilde{\gamma} Y - X_2\right]} \tag{23}$$

$$\tau_h\left[\delta Y - (\tilde{\gamma} Y - X_2)\right] \leq \frac{X_1 + F}{1 - \left[\frac{\bar{b}}{(1-\alpha_0)(1-\theta)}\right]} - (X_1 + F) \tag{24}$$

$$\frac{\tau_h\left[\delta Y - (\tilde{\gamma} Y - X_2)\right]}{\left[\frac{\left[\frac{b}{(1-\alpha_0)(1-\theta)}\right]}{\delta Y - (\tilde{\gamma} Y - X_2) - \left[\frac{b}{(1-\alpha_0)(1-\theta)}\right]}\right]} \leq (X_1 + F) \tag{25}$$

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This completes the proof. □

Proof of Proposition 1

First, we establish the following lemma regarding the impact of financing.

Lemma 3. *Holding fixed the entrepreneur's choice of strategy, the venture capitalist is indifferent between stage financing and upfront financing.*

Proof. To see this, note that with upfront financing she earns in expectation,

$$\theta\left(1-\frac{X_0+X_1}{\mathbb{E}\left[(1-\alpha_2)\,\gamma Y||\alpha_0\right]}\right)\mathbb{E}\left[(1-\alpha_2)\,\gamma Y||\alpha_0\right]= \tag{26}$$

$$\theta\left(\psi-X_0-X_1\right) \tag{27}$$

, where $\psi \equiv p_0\left[\tilde{\gamma}Y-X_2\right]+\tau\left[\delta Y-(\tilde{\gamma}Y-X_2)\right]$. By the same logic, if the low-risk strategy is chosen, she earns $\theta\left(\psi_0-X_0-X_1\right)$, where $\psi_0 \equiv p_0\left[\tilde{\gamma}Y-X_2\right]$. To simplify our notation, let $V_s^{\tau} \equiv \mathbb{E}\left[(1-\alpha_2)\,\gamma Y|p_s,\,\tau\right]=p_s\left[\tilde{\gamma}Y-X_2\right]+\tau\left[\delta Y-(\tilde{\gamma}Y-X_2)\right]$ denote the expected value of the (diluted) equity claim, conditional on the asset quality and the entrepreneur's choice of strategy. If stage financing incents the high-risk strategy regardless of asset quality, the venture capitalist's expected earnings are

$$\theta\left(1-\frac{X_0-F}{\mathbb{E}\left[(1-\alpha_1)\,(1-\alpha_2)\,\gamma Y|\alpha_0\right]}\right)\mathbb{E}\left[(1-\alpha_1)\,(1-\alpha_2)\,\gamma Y|\alpha_0\right]\text{where} \tag{28}$$

$$\mathbb{E}\left[(1-\alpha_1)\,(1-\alpha_2)\,\gamma Y|\alpha_0\right]=\left(q\left(1-\alpha_1(p_h)\right)V_h^{\tau_h}+(1-q)\left(1-\alpha_1(p_l)\right)V_l^{\tau_h}\right) \tag{29}$$

$$=\psi-(X_1+F) \quad \Longrightarrow \tag{30}$$

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$$\theta\left(1-\frac{X_0-F}{\mathbb{E}\left[\left(1-\alpha_1\right)\left(1-\alpha_2\right)\gamma Y|\alpha_0\right]}\right)\mathbb{E}\left[\left(1-\alpha_1\right)\left(1-\alpha_2\right)\gamma Y|\alpha_0\right]=\theta\left(\psi-X_0-X_1\right). \tag{31}$$

Again, by the same logic, if stage financing incents the low-risk strategy, her expected earnings are just $\theta\left(\psi_0-X_0-X_1\right)$. Thus, the only effect capital structure has on the expected value of the firm is through its effect on the entrepreneur's choice of strategy. doesn't matter as long as the entrepreneur takes the same action. □

With this established, we can complete the proof. Suppose that $p_e \geq \overline{p}$. Then the entrepreneur chooses the risky strategy, regardless of asset quality, as long as[34]

$$\left(1-\frac{X_1+F}{V_l^{\tau_h}}\right)\left(1-\frac{X_0-F}{q\left(V_h^{\tau_h}-\left(X_1+F\right)\right)+\left(1-q\right)\left(V_l^{\tau_h}-\left(X_1+F\right)\right)}\right)\geq\frac{\bar{b}}{1-\theta}. \tag{32}$$

If both (**??**) and (32) hold, the venture capitalist is indifferent between staged and upfront financing, by Lemma 3. To show that this will not always be the case, we can rewrite the left-hand side of (32) as

$$1-\frac{\left(X_1+F\right)\left[\psi-\left(X_1+F\right)\right]+\left(V_l^{\tau_h}-\left(X_1+F\right)\right)\left(X_0-F\right)}{\left[\psi-\left(X_1+F\right)\right]V_l^{\tau_h}}. \tag{33}$$

Second, with a little algebra it can be shown that

$$\frac{\left(X_1+F\right)\left[\psi-\left(X_1+F\right)\right]+\left(V_l^{\tau_h}-\left(X_1+F\right)\right)\left(X_0-F\right)}{\left[\psi-\left(X_1+F\right)\right]V_l^{\tau_h}}>\frac{X_0+X_1}{\psi}\quad\Longleftrightarrow \tag{34}$$

$$\left[X_0\right]\left(\left(\psi-V_l^{\tau_h}\right)\left(X_1+F\right)\right)-\left[X_1\right]\left[\psi-\left(X_1+F\right)\right]\left(\psi-V_l^{\tau_h}\right)<\psi F\left[\psi-V_l^{\tau_h}\right]\Longleftrightarrow \tag{35}$$

$$X_0+X_1<\psi \tag{36}$$

where the last inequality obviously holds because the firm is able to obtain financing upfront. Note that when we move from the second to the third inequality the sign stays the same because $\psi > V_l^{\tau_h}$. On the other hand, As a result, there exist parameters such that (**??**) holds but (32)

[34]There is less dilution at date one if the asset is revealed to be high-quality and so we focus on the incentive to take risk in the low-quality state.

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does not.[35] Under those conditions, if the firm uses staged financing and the asset is low quality, the entrepreneur chooses the low-risk strategy, which lowers the expected value of the venture capitalist's claim. Thus, she strictly prefers upfront financing under these conditions by Lemma 3.

To complete the proof, we consider the case when $p_e < \bar{p}$. If (32) does not hold, then $p_l < \bar{p}$, and so the entrepreneur cannot even finance the investment if the asset is low-quality. Further, by continuity of the diluted equity stake, parameter values exist such the investment cannot be financed in the low-state (even though (32) is not violated). Thus, by the same logic, upfront financing remains preferable when $p_e < \bar{p}$, sometimes strictly. □

Proof of Proposition 2

Suppose the firm is mid-value. If the entrepreneur chooses staged financing (and can finance the firm when it is revealed to be low-quality), then he chooses the high-risk strategy when the asset is high-quality as long as

$$\left(1 - \frac{X_1 + F}{V_h^{\tau_h}}\right)\left(1 - \frac{X_0 - F}{q\left(V_h^{\tau_h} - (X_1 + F)\right) + (1-q)\left(V_l^0 - (X_1 + F)\right)}\right) \geq \frac{\bar{b}}{1-\theta}. \tag{37}$$

Let $\psi_0 \equiv p_0\left[\tilde{\gamma}Y - X_2\right]$ and $\psi_1 \equiv p_0\left[\tilde{\gamma}Y - X_2\right] + q\tau\left[\delta Y - (\tilde{\gamma}Y - X_2)\right]$. Note that ψ_1 is the unconditional expectation of the diluted cash flow at date one - by the above proof, it is easy to show that the entrepreneur cannot choose the high-risk strategy if the asset is low-quality in this setting. On the other hand, following steps similar to those found in the proof of Proposition 1, we can show that

$$\frac{(X_1 + F)\left[\psi_1 - (X_1 + F)\right] + \left(V_h^{\tau_h} - (X_1 + F)\right)(X_0 - F)}{\left[\psi_1 - (X_1 + F)\right] V_h^{\tau_h}} < \frac{X_0 + X_1}{\psi_1} \tag{38}$$

as long as $X_0 + X_1 < \psi_1$. But of course this holds because the entrepreneur can successfully

[35] Using similar steps, it is straightforward to show that, under staged financing, a high-value firm always chooses the high-risk strategy when the asset is high-quality.

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engage in upfront financing, i.e., $X_0 + X_1 < \psi_0 < \psi_1$. Thus, if the firm receives financing (even when the asset is low-quality), staged financing creates the possibility of (37) holding, in which case the entrepreneur chooses the high-risk strategy when the asset is high-quality. Thus, the venture capitalist prefers staged financing, sometimes strictly, by Lemma 3.

If the entrepreneur chooses staged financing and cannot finance the firm when it revealed to be low-quality, he defaults some portion of the time. Knowing this, he chooses the high-risk strategy when the asset is high-quality as long as

$$\left(1 - \frac{X_1 + F}{V_h^{\tau_h}}\right)\left(1 - \frac{X_0 - qF}{q\left(V_h^{\tau_h} - (X_1 + F)\right)}\right) \geq \frac{\bar{b}}{1-\theta}. \tag{39}$$

If this doesn't hold, then the venture capitalist strictly prefers upfront financing by Lemma 3. First, we show that it is feasible for (39) to hold even though (**??**) does not.

$$\left(1 - \frac{X_1 + F}{V_h^{\tau_h}}\right)\left(1 - \frac{X_0 - qF}{q\left(V_h^{\tau_h} - (X_1 + F)\right)}\right) = 1 - \frac{qX_1 + X_0}{qV_h^{\tau_h}} \tag{40}$$

Then it is possible for the entrepreneur to choose the high-risk strategy (with staged financing) as long as

$$\frac{qX_1 + X_0}{qV_h^{\tau_h}} < \frac{X_0 + X_1}{\psi} \quad \Longleftrightarrow \tag{41}$$

$$X_0 V_l^{\tau_h} < qX_1\left(p_h - p_L\right)\left[\tilde{\gamma}Y - X_2\right] \tag{42}$$

It is clear this holds if $X_0 = 0$, for example. Second, the venture capitalist would prefers staged financing over upfront financing as long as:

$$\theta\left(\psi_0 - X_0 - X_1\right) < \theta\left(q\left[V_h^{\tau_h} - (X_1 + F)\right] - (X_0 - qF)\right) \iff \tag{43}$$

$$(1-q)\left(V_l^0 - X_1\right) < q\left(\tau_h\left[\delta Y - (\tilde{\gamma}Y - X_2)\right]\right). \tag{44}$$

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which clearly holds if $X_1 = V_l^0$. Under these assumptions, the venture capitalist can still raise capital because $X_0 + X_1 = V_l^0 < (1-q)V_l^0 + qV_h^0$. Thus, conditions exist under which the venture capitalist prefers staged financing to upfront financing, even though she cannot raise capital with a low-quality asset.

Now, we formally establish the thresholds such that staged financing is preferable. First, we note that

$$1 - \frac{qX_1 + X_0}{qV_h^{\tau_h}} \geq \frac{\bar{b}}{1-\theta} \iff \tag{45}$$

$$p_h \geq \frac{\frac{qX_1+X_0}{q\left(1-\frac{\bar{b}}{1-\theta}\right)} - \tau_h\left[\delta Y - (\tilde{\gamma}Y - X_2)\right]}{\left[\tilde{\gamma}Y - X_2\right]} \equiv \underline{p_h} \tag{46}$$

Second, we show that if this holds, there exists an upper bound on p_l such that the venture capitalist prefers staged financing to upfront financing:

$$\theta\left(\psi_0 - X_0 - X_1\right) \leq \theta\left(q\left[V_h^{\tau_h} - (X_1 + F)\right] - (X_0 - qF)\right) \iff \tag{47}$$

$$p_l \leq \frac{X_1(1-q) + q\tau_h\left[\delta Y - (\tilde{\gamma}Y - X_2)\right]}{(1-q)\left[\tilde{\gamma}Y - X_2\right]} \equiv \overline{p_l} \tag{48}$$

Finally, we show that the low-value firm prefers staged financing, sometimes strictly. In this case, we need to establish that it is possible for the firm to raise capital in the high-quality state, even though $X_0 + X_1 > \psi_0$. The venture capitalist can raise capital at date one if the firm is revealed to be high-quality as long as $p_h\left[\tilde{\gamma}Y - X_2\right] \geq X_1 + F$ and at date zero as long as $\alpha_0 \leq 1$, i.e.

$$X_0 - qF \leq \mathbb{E}\left[(1-\alpha_1)(1-\alpha_2)\gamma Y | \alpha_0\right] \tag{49}$$

$$X_0 - qF \leq q\left[p_h\left[\tilde{\gamma}Y - X_2\right] - (X_1 + F)\right] \tag{50}$$

$$X_0 \leq q\left[p_h\left[\tilde{\gamma}Y - X_2\right] - X_1\right] \tag{51}$$

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Suppose that $X_0 = F = 0$ and let $X_1 = p_h\left[\tilde{\gamma}Y - X_2\right]$. Then the entrepreneur can raise the capital necessary if the asset turns out to be high-quality. Moreover, it is still the case that $X_1 = p_h\left[\tilde{\gamma}Y - X_2\right] > p_0\left[\tilde{\gamma}Y - X_2\right] = \psi_0$. $\square$

Proof of Proposition 3

We will start by focusing on the setting in which the firm is mid-value and the firm can raise capital in the low-state. Let

$$\left(1 - \frac{X_1 + F}{V_h^{\tau_h}}\right)\left(1 - \frac{X_0 - F}{\psi_1 - (X_1 + F)}\right) \equiv \chi. \tag{52}$$

Then, we want to show that issuing venture debt can induce the entrepreneur to choose the high-risk strategy when staged equity financing was insufficient to get (8) to hold. Specifically, we want to show that $\frac{\partial \chi}{\partial F} > 0$.

$$\frac{\partial \chi}{\partial F} = -\left(1 - \frac{X_0 - F}{\psi_1 - (X_1 + F)}\right)\left(\frac{1}{V_h^{\tau_h}}\right) - \left(1 - \frac{X_1 + F}{V_h^{\tau_h}}\right)\left(\frac{-\left(\psi_1 - (X_1 + F)\right) + X_0 - F}{\left(\psi_1 - (X_1 + F)\right)^2}\right) \tag{53}$$

$$= \left(\frac{-1}{V_h^{\tau_h}}\right)\left[\left(1 - \frac{X_0 - F}{\psi_1 - (X_1 + F)}\right) + \left(V_h^{\tau_h} - (X_1 + F)\right)\left(\frac{X_1 + X_0 - \psi_1}{\left(\psi_1 - (X_1 + F)\right)^2}\right)\right] \tag{54}$$

We want to show that the term in brackets is less than zero, that is

$$\left(1 - \frac{X_0 - F}{\psi_1 - (X_1 + F)}\right) < \left(V_h^{\tau_h} - (X_1 + F)\right)\left(\frac{\psi_1 - (X_0 + X_1)}{\left(\psi_1 - (X_1 + F)\right)^2}\right) \tag{55}$$

$$\left(\frac{\psi_1 - (X_1 + X_0)}{\psi_1 - (X_1 + F)}\right) < \left(V_h^{\tau_h} - (X_1 + F)\right)\left(\frac{\psi_1 - (X_0 + X_1)}{\left(\psi_1 - (X_1 + F)\right)^2}\right) \tag{56}$$

Note that $\psi_1 > \psi_0 > X_1 + X_0$ (upfront financing is feasible) and $\psi_1 > p_l\left[\tilde{\gamma}Y - X_2\right] > X_1 + F$ (date one financing with a low-quality asset is feasible). Thus, we can rewrite the inequality

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above,

$$1 < \left(\frac{V_h^{\tau_h} - (X_1 + F)}{\psi_1 - (X_1 + F)} \right), \tag{57}$$

which of course holds because $\psi_1 = qV_h^{\tau_h} + (1-q)V_l^0 < V_h^{\tau_h}$ and both are greater than $X_1 + F$ (date one financing with the high-quality asset is feasible). Thus, $\frac{\partial \chi}{\partial F} > 0$.

On the flip side, issuing venture debt makes it less likely that the firm can obtain financing if it owns a low-quality asset. If financing fails with a low-quality asset, then we are in the second case of proposition 2; here, venture debt does not slacken the incentive compatibility constraint and so if low-quality financing fails, no venture debt is utilized.[36]

Finally, to establish under what conditions we are more likely to observe venture debt, it is straightforward to see that $\frac{\partial \chi}{\partial X_0}, \frac{\partial \chi}{\partial X_1}, \frac{\partial \chi}{\partial X_2} < 0$, whereas $\frac{\partial \chi}{\partial \delta}, \frac{\partial \chi}{\partial Y}, \frac{\partial \chi}{\partial \tau_h}, \frac{\partial \chi}{\partial \tilde{\gamma}}, \frac{\partial \chi}{\partial p_0} > 0$. On the other side, $\bar{b}$ is always decreasing in δ (consistent with the partial effects on χ), but can increase in Y, $\tilde{\gamma}$, X_2. □

Proof of Corollary 1

The optimal use of venture debt increases the expected value of the firm because it induces the entrepreneur to take risk if the asset is revealed to be high-quality. At date two, this (1) increases the likelihood of failure (unable to raise funds) and (2) increases the expected value of the firm, conditional on successfully raising capital. The value of venture debt is that it decreases dilution if the asset is revealed to be high-quality. □

[36] This will not necessarily hold under more general assumptions about the distribution of p_1.

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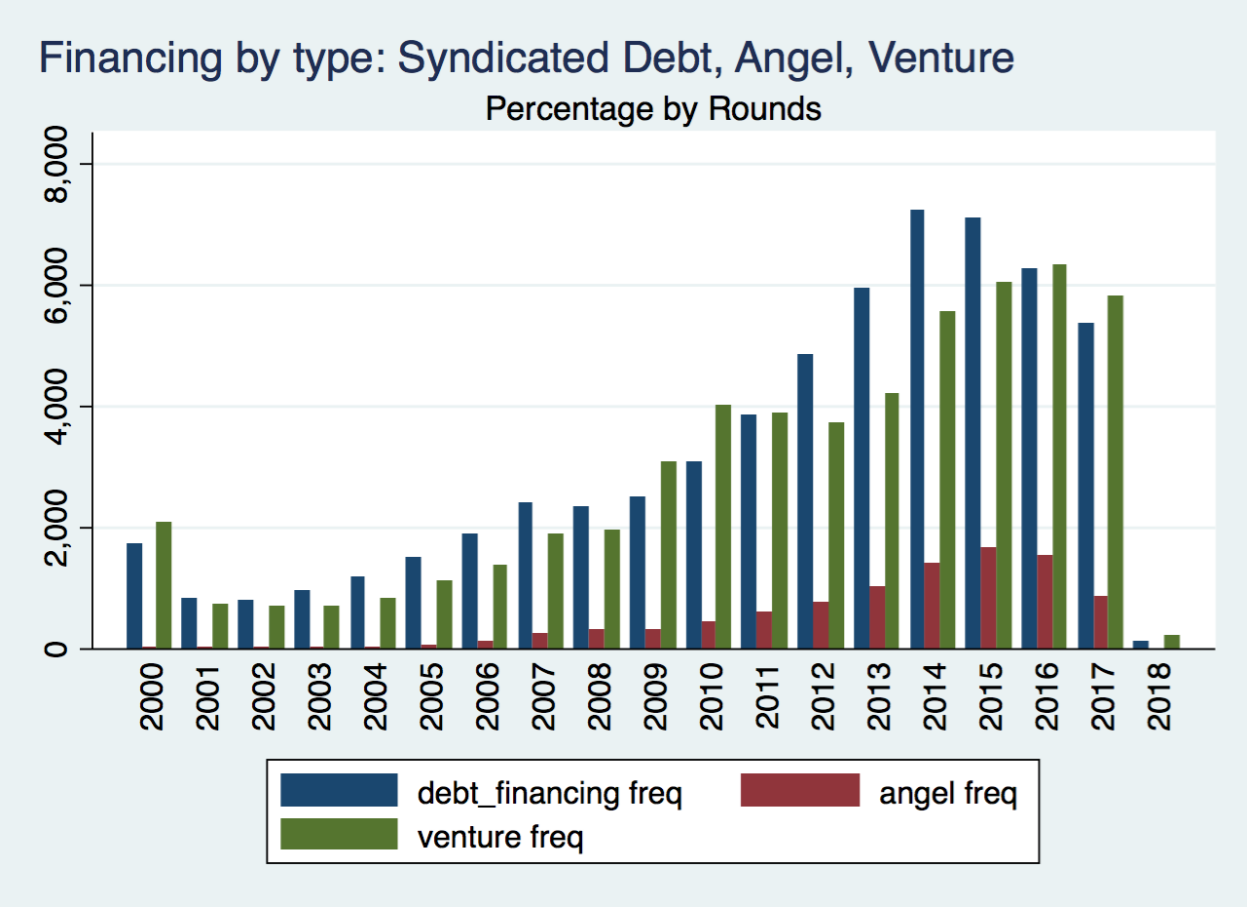


Figure 1: Type of Financing Rounds by Funding Year

Depicted are the frequency of financing rounds by type {venture debt, venture equity, angel financing} based on year of funding round..

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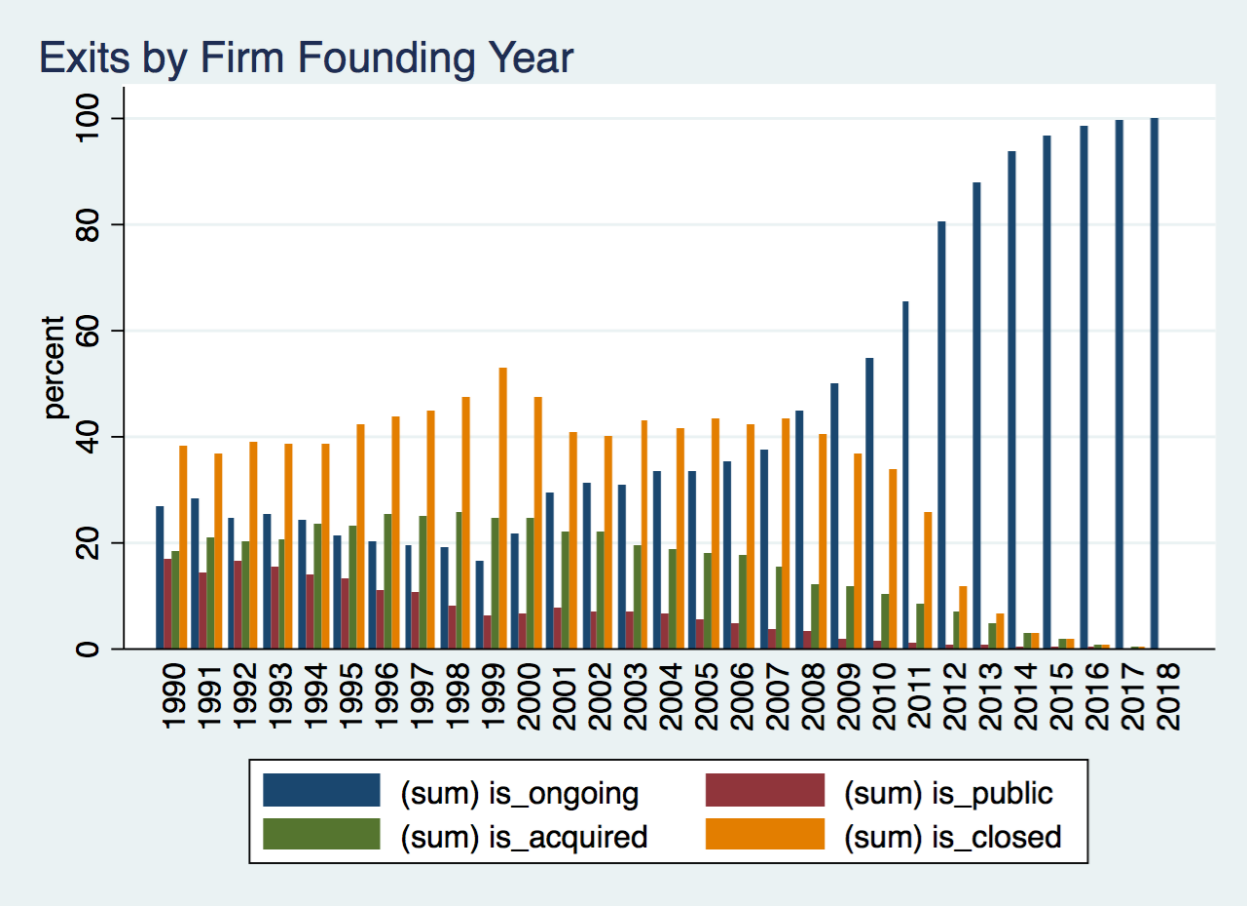


Figure 2: Exits by Firm Founding Year

Depicted are the firm exits {Ongoing, Acquisition, IPO, and Closing} as a percent of firms starting in the year on the x-axis.

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"Innovation Industry Lender" Mentality

A twist on the traditional credit model

- **Primary source of repayment: cash-flow from *future equity***
  - Question: what is the probability that the investors will provide additional equity sufficient to support operations and repay the loan?

- **Secondary source of repayment: enterprise value**
  - Question: what is the probability that the enterprise value (IP, customer base, licenses, etc.) is sufficient to repay the loan should the venture support prove insufficient?

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Figure 3: Milestone-Based Valution, With and Without Debt

Panels A and B depict an example of firm valuation outcomes when startups run out of cash before hitting their mileston. Startups are then forced to either raise at a lower than expected valuation or shut-down. Panels C and D depict the same scenario with the introduction of venture debt.

As described in the text, not depicted is the distribution of firms shutting down with and without debt. In particular, our model suggests that the probability of ending up in Panel D is greater that of ending up in Panel B.

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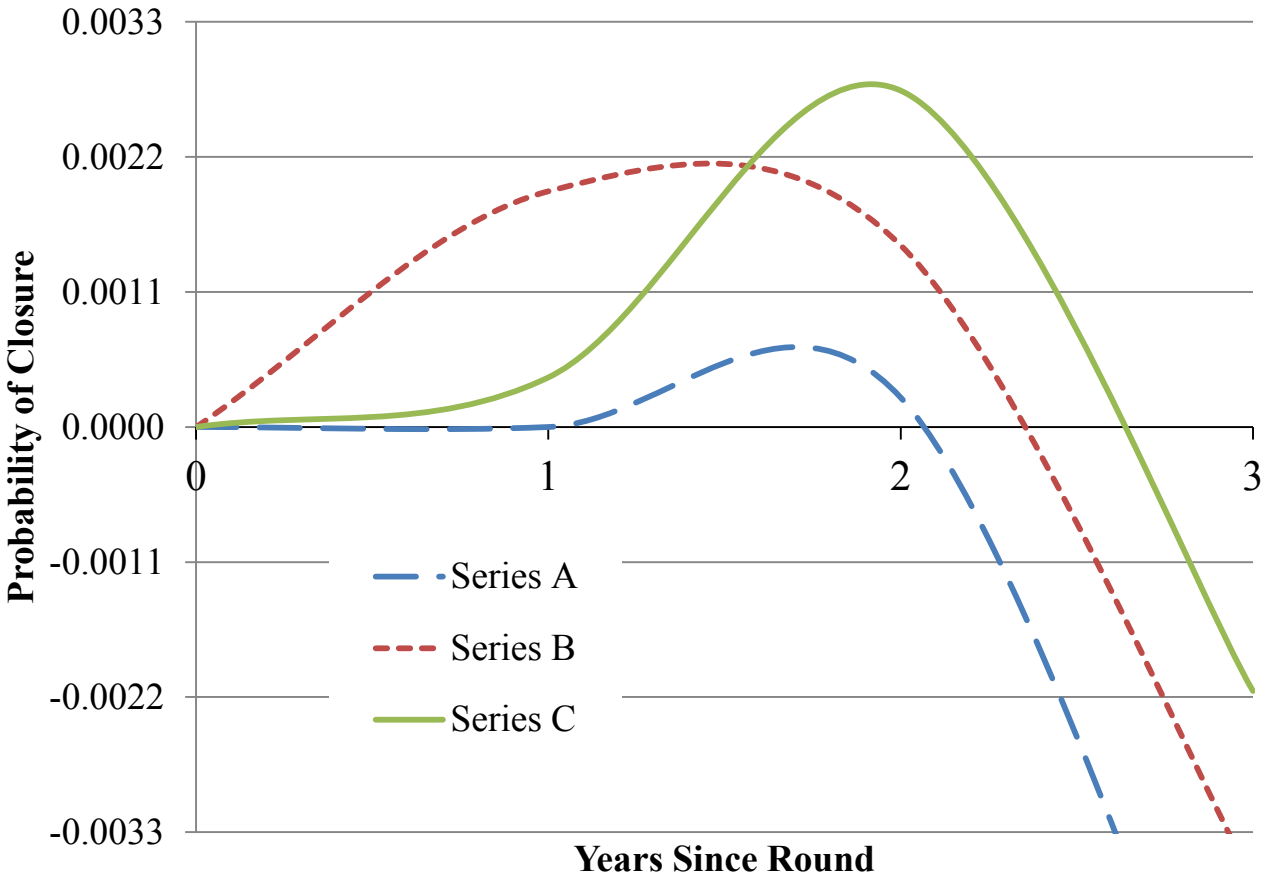


Figure 3: The Effect of a Round Involving Debt on Future Closure

Depicted are the Debt Round indicator mearginal effects from fifteen logit estimations of the probability that the startup closes within the x-axis time frame as a function of whether the round is a Debt Round, the log investment size of the round, and round year fixed effects. The estimation table is provided as Appendix Table 1.

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Table 1: Company Level Summary Statistics

Reported are summary statistics at the startup company level (1 observation per company). The number of rounds is the count of investment rounds in Crunchabse. The Percent of Rounds that are Debt are the percent of the Number of Rounds that are debt rounds or debt syndicated with equity. Early debt is defined to be debt that is issued prior to Series B financing. Total Investment is the dollar value of investments. Total Debt ROund Investmens include the sums of debt rounds and debt syndicated rounds. Within the exit breakdowns, the Closed/Inactive firms includes all firms marked as closed plus those who have experience no update in the last two years.

	Mean	St. Dev.	25th%tile	Median	75th%ile
Number of Rounds	2.05	1.59	1	1	3
Percentage of Rounds that are Debt	35.85%	47.95%	0	0	1
Percentage of Rounds that are Early Debt	26.30%	44.03%	0	0	1
Total Investment	14,800,000	73,000,000	300,000	1,650,000	8,150,000
Log Total Investment	14.54	1.93	12.89	14.37	15.92
Total Debt Round Investment	7,508,000	49,400,000	0	0	6,000,000
Log Total Debt Round Investment	12.71	2.11	11.51	11.51	13.45
Total Early Debt Round Investment	2,342,000	30,500,000	0	0	0
Log Total Early Debt Round Investment	12.34	1.64	11.51	11.51	11.51
Year of First Financing	2012.48	3.59	2011	2013	2015
Exit Distribution					
Ongoing	70.99%		0	1	1
Resolved	29.01%		0	0	1
Acquired	33.87%		0	0	1
IPO	7.00%		0	0	0
Closed/Inactive	59.13%		0	1	1
Observations	62,403				

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Table 2: Financing Rounds Summary Statistics

Reported are means and standard deviations of round financing-level data. The Series show in the different panels is the actual round (for equity rounds or equity-debt syndicate rounds) or the would-be round for debt financing had the firm issued a equity round. Current Round Investment is the dollar value of the investment. Dilution Proxy is Current Investment divded by the sum of current + the immediate prior investment round. . The pre-money valuation, which is sparsely reported in Crunchbase, is the valuation accruing to founders and prior investors as implied by the valuation of the current investment. Burn Rate Duration is the number of days forward until the next financing. The final colum test for the difference in means of the Equity veruss Debt rounds within the Series.

	Seed/Series A						
	Equity Rounds			Debt or Debt Syndicate			Mean
	Mean	SD	Obs.	Mean	SD	Obs.	Different
Current Round Investment	2,343,715	15,300,000	47,512	9,335,287	41,300,000	13,605	***
Log Current Investment	13.16	1.73	47,512	15.02	1.51	13,605	***
Dilution Proxy	0.574	0.247	13,444	0.624	0.250	7,411	***
Pre-Money Valuation	17,800,000	196,000,000	4,810	213,000,000	1,020,000,000	421	*
Days to Next Financing	14.58	1.48	4,810	15.85	2.16	421	***
Burn Rate Duration (days)	475	438	25,521	479	391	9,333	***
Financing Year	2013.1	3.5	62,895	2011.6	4.6	15,824	
	Series B						
	Equity Rounds			Debt or Debt Syndicate			Mean
	Mean	SD	Obs.	Mean	SD	Obs.	Different
Current Round Investment	10,600,000	33,200,000	7,069	15,900,000	40,900,000	9,324	***
Log Current Investment	15.30	1.40	7,069	15.77	1.48	9,324	***
Dilution Proxy	0.510	0.238	5,505	0.556	0.232	7,920	***
Pre-Money Valuation	225,000,000	729,000,000	237	290,000,000	1,150,000,000	306	
Log Pre-Money	17.11	2.00	237	17.28	2.27	306	
Days to Next Financing	541	507	4,246	540	446	6,167	
Financing Year	2011.5	4.9	8,470	2010.6	5.1	10,228	***
	Series C						
	Equity Rounds			Debt or Debt Syndicate			Mean
	Mean	SD	Obs.	Mean	SD	Obs.	Different
Current Round Investment	13,600,000	35,400,000	3,500	21,600,000	37,700,000	5,422	***
Log Current Investment	15.46	1.47	3,500	16.11	1.49	5,422	***
Dilution Proxy	0.382	0.233	3,113	0.432	0.219	5,010	***
Pre-Money Valuation	454,000,000	1,320,000,000	117	462,000,000	847,000,000	206	
Log Pre-Money	17.97	2.14	117	18.59	2.09	206	**
Days to Next Financing	498	485	2,202	528	450	3,477	**
Financing Year	2011.5	4.7	4,182	2010.6	4.9	5,848	***
	Series D						
	Equity Rounds			Debt or Debt Syndicate			Mean
	Mean	SD	Obs.	Mean	SD	Obs.	Different
Current Round Investment	18,800,000	51,700,000	1,900	26,600,000	52,500,000	2,657	***
Log Current Investment	15.56	1.59	1,900	16.18	1.57	2,657	***
Dilution Proxy	0.299	0.220	1,813	0.335	0.203	2,577	***
Pre-Money Valuation	637,000,000	811,000,000	72	831,000,000	1,160,000,000	142	
Log Pre-Money	18.94	2.12	72	19.51	1.98	142	*
Burn Rate Duration (days)	454	449	1,167	507	467	1,741	***
Financing Year	2012	4.3	2,193	2011	4.4	2,901	***

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Table 3: Effect of Dilution on the Choice of Debt versus Equity

The dependent variable is the choice of venture debt versus venture equity for each round of financing. The estimation is via logit, and the marginal effects are reported. Each column subsamples only to estimate rounds for Seed + Series A (cols 1-2), Series B (3-4), Series C (5-6), or Series D (7-8). The series letter is the actual round (for equity rounds or equity-debt syndicate rounds) or the would-be round for debt financing had the firm issued a equity round. The independent variable of interest is a proxy for dilution in this round; namely, cumulative entrepreneurial equity dilution. Financing year fixed effects are included. Errors are clustered by company. ***, **, and * denote significance at standard 1%, 5% and 10% levels.

	Logit: Debt Issuance *(Marginal Effects Shown)*							
	Seed + Series A		Series B		Series C		Series D+	
Dilution	1.325***		0.654***		0.291		0.104	
	[0.103]		[0.216]		[0.327]		[0.345]	
Dilution Proxy: Current:Cumulative Investment		0.116**		0.302***		0.417***		0.440***
		[0.0455]		[0.104]		[0.124]		[0.0996]
Controls:								
Year Polynomial	Y	Y	Y	Y	Y	Y	Y	Y
F.E. Founding Year	Y	Y	Y	Y	Y	Y	Y	Y
F.E. Lag Pre-Money	Y	Y	Y	Y	Y	Y	Y	Y
Log Current Investment		Y		Y		Y		Y
F.E. Prior Investment		Y		Y		Y		Y
Observations	24,807	24,807	12,280	12,280	6,953	6,953	7,436	7,436
Pseudo R-squared	0.0721	0.0785	0.0954	0.102	0.105	0.116	0.0597	0.0786
1 SD of Dilution	0.0517		0.0326		--		--	
Effect of Dilution	6.85%		2.13%		--		--	
In %Change	27%		4%		--		--	
1 SD of Dilution Proxy		0.2588		0.2665		0.2458		0.2047
Effect of Dilution Proxy		3%		8%		10%		9%
In %Change		12%		17%		19%		17%
Choice Variable Mean	0.2521	0.2521	0.4844	0.4844	0.5429	0.5429	0.5257	0.5257

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Table 4: Effect of Valuation on the Choice of Debt versus Equity

The dependent variable is the choice of venture debt and syndicated debt and equity for each round of financing. The estimation is multinomial logit and the omitted category is the equity-only round. Each column subsamples only to estimate rounds for Series A (cols 1-2), Series B (3-4), Series C (5-6), or D (7-8). The independent variable of interest, Low Quintile Value Gain, is an indicator variable for a low increase in valuation relative to the prior financing round. The other independent variable is the dilution proxy. Financing round year and founding year fixed effects are included. Errors are clustered by company. ***, **, and * reflect significance at standard 1%, 5% and 10% levels.

	Multinomial Logit : Omitted Category is Equity-Only Round							
	Estimation 1 Series A		Estimation 2 Series B		Estimation 3 Series C		Estimation 4 Series D+	
	Debt + Equity	Debt Only	Debt + Equity	Debt Only	Debt + Equity	Debt Only	Debt + Equity	Debt Only
Low Quintile Value Gain	-0.275***	0.102***	-0.373***	0.071***	-0.422***	0.101***	-0.338***	0.167***
	[0.0115]	[0.00454]	[0.0158]	[0.00709]	[0.0200]	[0.00959]	[0.0175]	[0.0104]
Dilution	0.733***	-0.0642	0.560**	-0.0401	0.425	-0.102	0.191	-0.0451
	[0.173]	[0.0523]	[0.248]	[0.0376]	[0.338]	[0.0820]	[0.293]	[0.148]
Year Polynomial	Y		Y		Y		Y	
F.E. Founding Year	Y		Y		Y		Y	
F.E. Lag Pre-Money	Y		Y		Y		Y	
Observations	13,415		12,280		6,955		7,436	
Pseudo R-squared	0.093		0.142		0.174		0.132	
1 SD of Dilution	0.0467	--	0.0326	--	--	--	--	--
Effect of Dilution	3.42%	--	1.83%	--	--	--	--	--
In %Change	9%		4%					
1 SD of Weak Value Gain	0.2803	0.2803	0.3323	0.3323	0.3654	0.3654	0.1946	0.1946
Effect of Weak Gain	-8%	3%	-12%	2%	-15%	4%	-6%	3%
In %Change	-20%	28%	-29%	39%	-34%	43%	-18%	20%
Choice Variable Mean	0.3783	0.1023	0.4232	0.0612	0.4568	0.0862	0.3615	0.1642

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Table 5: Time Between Rounds

The dependent variable is the log the number of days from the financing round indicated in the column until the next financing round, with the unit of observation being a round of finance. The series letter (A, B, C or D) is the actual round (for equity rounds or equity-debt syndicate rounds) or the would-be round for debt financing had the firm issued a equity round. The independent variable of interest, Debt Round, is the choice of venture debt (alone or syndicated) versus venture equity for each round. The other independent variable is the log of the money raised in the current investment round. Round year fixed effects are included. Errors are clustered by company. ***, **, and * reflect significance at standard 1%, 5% and 10% levels.

	Log Duration (days) until Next Round			
	OLS with Fixed Effects			
	Seed + Series A	Series B	Series C	Series D+
Debt + Equity Round	-0.0826***	0.0855***	0.0774**	0.0837**
	[0.0134]	[0.0250]	[0.0378]	[0.0397]
Debt Only Round	-0.318***	-0.320***	-0.279***	-0.254***
	[0.0473]	[0.0525]	[0.0556]	[0.0482]
Log (Investment)	0.128***	0.109***	0.108***	0.128***
	[0.00426]	[0.0123]	[0.0153]	[0.0157]
F.E. Funding Year	Y	Y	Y	Y
F.E. Founding Year	Y	Y	Y	Y
F.E. Lag Pre-Money	Y	Y	Y	Y
F.E. Prior Investment	Y	Y	Y	Y
Observations	31,020	7,105	4,036	4,397
R-squared	0.109	0.142	0.156	0.165
Mean Duration (days)	465	511	475	429.7
Mean Log Duration	5.76	5.89	5.78	5.66

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Table 6: Closing as a Function of the Total Debt Financing Round Invesment Dollars

The dependent variable is an indicator for the startup closing. The unit of observation is a startup firm. The estimation is logit, reporting the marginal effects effect for a change in the probability of closing. The independent variables capture the total money raised by the startup (Log Total Investment), the total money raised in a debt or debt syndicated round, and the total money raised in a debt or debt syndicated round prior to a Series B equity round. A debt syndicate round is one in which debt and equity are together included in the financing package. We cannot disentangle the relative amounts. Included are fixed effects for the first financing roung year and the count of total investment roungs. ***, **, and * reflect significance at standard 1%, 5% and 10% levels with robust standard errors.

	Logit: Closed	
	Collapsed to 1 Observation per Firm	
Log Total Investment	-0.0228***	-0.0228***
	[0.00114]	[0.00114]
Log Debt Investment	-0.00104	-0.00568***
	[0.000967]	[0.00162]
Log Debt Investment Prior to Series B		0.00647***
		[0.00179]
Fixed Effects:		
Founding Year	Y	Y
First Funding Year	Y	Y
Investment Rounds	Y	Y
Observations	62,401	62,401
Pseudo R-squared	0.147	0.147

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Table 7: Hazard Model of Closure Risk

The dependent variable is an indicator for the startup closing where each observation here is a round-year. Column 1 begins at Seed + Series A rounds; column 2 at Series B; column 3 at Series C; column 4 at Seires D+. The estimation is cox proportional hazard, reporting the hazard rate. The independent variable of interest, Debt Round, is the choice of venture debt versus venture equity for each round. The other independent variable is the log of the money raised in the current investment round. Control variables include prior investments and lag pre-money valuation. Round year, age, economy year fixed effects are included. Errors are clustered by company. ***, **, and * reflect significance at standard 1%, 5% and 10% levels.

	Cox Proportional Hazard Analysis of Closure Risk Sample: Funding Round Agings			
	Seed+Series A	Series B	Series C	Series D+
Debt Round	1.109***	0.888*	0.787**	0.783**
	[0.0388]	[0.0590]	[0.0740]	[0.0893]
Log (Investment)	0.898***	0.882***	0.854***	0.885***
	[0.00729]	[0.0228]	[0.0318]	[0.0286]
Controls				
F.E. Prior Investments	Y	Y	Y	Y
F.E. Lag Pre-Money Valuation	Y	Y	Y	Y
Cubic Polynomial of Age of Firm at Funding	Y	Y	Y	Y
Cubic Polynomial of Economy Year	Y	Y	Y	Y
Cubic Polynomial of Funding Round Year	Y	Y	Y	Y
Subjects (Unique Funding Rounds)	61,264	10,049	5,543	5,819
Failures	7,288	1,091	532	520
Observations at Risk	232,972	43,674	23,299	21,307

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Table 8: Exit Outcomes (Acquisition and IPO), Conditional on Survival

The dependent variable is the exit outcome {IPO, Acquisition} of the startup conditional on it not closing before 2018. Each observation here is a round-year. Column 1 begins at Seed + Series A rounds; column 2 at Series B; column 3 at Series C; column 4 at Seires D+. The estimation is cox proportional hazard, reporting the hazard rate. The independent variable of interest, Debt Round, is the choice of venture debt versus venture equity for each round. The other independent variable is the log of the money raised in the current investment round. Control variables include prior investments and lag pre-money valuation. Round year, age, economy year fixed effects are included. Errors are clustered by company. ***, **, and * reflect significance at standard 1%, 5% and 10% levels.

	Cox Proportional Hazard Analysis of Exit Risk							
	Sample: Funding Round Agings							
	Seed + Series A		Series B		Series C		Series D+	
	Acquisition	IPO	Acquisition	IPO	Acquisition	IPO	Acquisition	IPO
Debt Round	2.184***	1.018	1.349***	0.995	1.376***	1.042	1.269**	1.351**
	[0.141]	[0.125]	[0.0991]	[0.106]	[0.133]	[0.123]	[0.138]	[0.161]
Log (Investment)	1.122***	1.417***	0.963	1.358***	0.908**	1.315***	0.878***	1.317***
	[0.0182]	[0.0436]	[0.0290]	[0.0858]	[0.0342]	[0.0661]	[0.0323]	[0.0647]
Controls								
F.E. Prior Investments	Y	Y	Y	Y	Y	Y	Y	Y
F.E. Lag Pre-Money Valuation	Y	Y	Y	Y	Y	Y	Y	Y
Cubic Polynomial of Age of Firm at Funding	Y	Y	Y	Y	Y	Y	Y	Y
Cubic Polynomial of Economy Year	Y	Y	Y	Y	Y	Y	Y	Y
Cubic Polynomial of Funding Round Year	Y	Y	Y	Y	Y	Y	Y	Y
Subjects (Unique Funding Rounds)	61,264	61,264	10,049	10,049	5,543	5,543	5,819	5,819
Exits	1,892	570	982	480	596	389	494	521
Observations at Risk	232,972	232,972	43,674	43,674	23,299	23,299	21,307	21,307

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Appendix Table 1: Years to Closing

The dependent variable is an indicator for the startup closing within the column years from the financing round to the years indicated in the columns. Panel A starts at Series A rounds; panel B, at Series B; and panel C, at Series C. The unit of observation is a round of finance. The estimation is logit, reporting the marginal effects effect for a change in the probability of closing. We exclude later rounds because of the shortness of horizon for estimation. The independent variable of interest, Debt Round, is the choice of venture debt versus venture equity for each round. The other independent variable is the log of the money raised in the current investment round. Round year fixed effects are included. Errors are clustered by company. ***, **, and * reflect significance at standard 1%, 5% and 10% levels.

Panel A: Observations forward from Rounds at Series A					
Dependent Variable:	Startup Closes in Period from the Financing Round up to the Years (below):				
	1	2	3	4	5
Debt Round	0.00154***	0.000249	-0.00625***	-0.00718***	-0.00494***
	[0.000589]	[0.000839]	[0.00196]	[0.00196]	[0.00143]
Log Current Investment	0.00000275	0.0000167	-0.00307***	-0.00392***	-0.00335***
	[0.000191]	[0.000290]	[0.000689]	[0.000737]	[0.000676]
Observations	23,346	22,338	19,818	15,953	13,875
Panel B: Observations forward from Rounds at Series B					
	Startup Closes in Period from the Financing Round up to the Years (below):				
	1	2	3	4	5
Debt Round	0.00192**	0.00148	-0.00369**	-0.00441***	-0.00566**
	[0.000788]	[0.00116]	[0.00158]	[0.00149]	[0.00234]
Log Current Investment	-0.000315	-0.000355	-0.00305***	-0.00267***	-0.00355***
	[0.000257]	[0.000351]	[0.000574]	[0.000601]	[0.000865]
Observations	15,237	13,842	12,958	11,285	8,220
Panel C: Observations forward from Rounds at Series C					
	Startup Closes in Period from the Financing Round up to the Years (below):				
	1	2	3	4	5
Debt Round	0.000404	0.00274	-0.00215	0.000612	-0.00449
	[0.00115]	[0.00169]	[0.00324]	[0.00444]	[0.00352]
Log Current Investment	-0.000453	-0.000809	-0.00316***	-0.00500***	-0.00430***
	[0.000377]	[0.000506]	[0.00101]	[0.00147]	[0.00124]
Observations	7,573	6,675	5,514	4,244	4,442

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