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Does Security Choice Matter in Venture Capital? The Case of Venture Debt

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Abstract

The switch from equity to debt in venture capital-backed entrepreneurial firms is rare, but uniquely informative. Using a novel dataset of financing decisions, we find that entrepreneurial firms that raise debt financing suffer from an average 40% post-debt valuation drop and a 26% lower probability of successful exit (IPO/acquisition). Venture capitalists with equity stakes lend to lower quality entrepreneurial firms compared to outside lenders, and debt from both precedes deterioration in firm quality. Our results do not imply that debt causes negative outcomes. Rather, we argue that debt helps maintain incentive alignment after adverse shocks to firm quality.

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Empirical studies on the relationship between a firm's prospects and its financing policy traditionally focus on publicly-traded firms. Due to data availability, the determinants of the security choices of young, private entrepreneurial firms are relatively unexplored.[1] The financing environment of such firms is unique. Venture capital (VC)-backed entrepreneurial firms receive financing from inside investors who are informed about firm quality and help determine firm financing decisions.[2] The environment contrasts with the setup of public firms that raise financing from arm's length investors who face information asymmetry about firm prospects. In this paper, we seek to determine how these differences affect financing decisions and firm outcomes of VC-backed firms in particular and firms in general.

Traditional explanations for debt financing do not easily apply in the VC setting. Since the investor is also an insider, the entrepreneur need not signal firm quality to the VC. Moreover, such firms rarely have taxable income, ruling out tax shield benefits as the motivation for debt issuance. Why then do VC-backed firms issue debt?

Empirical research on capital structure suggests that leverage increase is positively related to firm value.[3] In contrast, our analysis reveals that entrepreneurial firms that issue debt exhibit a reduction in firm value after obtaining debt and a lower probability of a successful exit (an initial public offering (IPO) or a private sale of the firm). We distinguish between two sources of debt: insiders, who are existing equity holders, and outsiders, who are new investors. Inside investors provide debt financing to lower quality firms than outside investors and debt from the former precedes significantly larger falls in valuation. If debt were causing the deterioration in firm prospects, then inside investors would not jeopardize their own firms more

[1] Brav (2009) studies private firm capital structure in the UK. Robb and Robinson (forthcoming) find that startups rely heavily on formal debt sources, such as bank financing.

[2] Venture capitalists possess in-depth knowledge of firm operations and industry expertise (see Lerner (1995) and Hellmann and Puri (2002)).

[3] See Masulis (1980) and Asquith and Mullins (1986), among others.

often than outside investors. Hence, we argue that debt financing in VC is likely a response to an adverse shock to firm prospects. We formalize this idea using a simple model and obtain an insight relevant to all firms: the information content of debt financing depends on whether insiders or outsiders are providing that debt.

The empirical analysis uses a comprehensive database of venture capital financings from VentureSource that covers 20 years and 22,000 entrepreneurial firms. The data distinguishes debt and equity financings, where debt includes loans, lines of credit, capital leases, or fully convertible debt. We focus on straight non-convertible debt, 83% of which involves simple debt contracts. Approximately 12% of venture-backed firms have raised straight, non-convertible debt, where such debt accounts for 7% of the amount of capital raised from 1990–2010. Compared to equity, debt occurs later in a firm's life, involves less capital, and occurs in relatively more profitable firms. Although debt is a relatively small fraction of both dollars and financing events, the rare switch between the two proves to be informative.

Our dataset also allows us to identify the sources of debt, which we classify into two categories. "Inside debt" is capital provided only by investors who already own some equity in the firm, while "outside debt" is capital from non-equity holders, such as venture lenders. In our sample, 52% of debt is from insiders. The average amount of debt provided by insiders is \$4.9m and represents 30% of all capital raised by the firm. In comparison, outside debt financings average \$7.8m, representing 36% of total capital raised. At the time of the financing, firms that receive debt from outside investors have raised more capital, are younger, and obtain debt from larger, more experienced investors than those firms that receive inside debt. A richer panel and cross-sectional analysis of firm valuation and success rates reveals a previously unhighlighted role of straight debt in the VC-backed entrepreneurial firm.

Using the panel of financings and firm valuation, the major empirical analysis

estimates an entrepreneurial firm fixed effects model. Figure 1 details the estimated changes in entrepreneurial firm value around a typical debt financing. The estimates imply that the average firm that raises debt has a 40% fall in equity value after the financing. The specifications control for the financing year, firm age and the development stage of the firm and results are robust to several valuation measures, selection corrections and the exclusion of failed firms. Comparing firms that raise debt to a set of equity-only firms with a difference-in-difference estimator confirms these conclusions. Overall, the estimates show that entrepreneurial firms that obtain debt are more likely to do so before an observed fall in equity valuation.

The negative relationship between debt financing and firm quality also manifests itself in cross-sectional outcomes. Approximately 2,220 firms that raise debt have a 26% lower probability of an IPO or high-valued acquisition compared to the mean likelihood of 23%.[4] Firms that obtain debt financing have lower total value created at exit and a 12% higher probability of CEO change. These negative relationships are not driven by defaulting firms. Either firms that borrow are of lower quality, or raising debt causes the deterioration in the firm's prospects. Distinguishing firm outcomes based on the financing source can help shed light on the correct explanation.

For both inside and outside debt, we find that firm quality is lower after the debt financing. Fixed effect panel estimates show that outside debt precedes 21% lower reduction in equity values than inside debt. Moreover, entrepreneurial firms that receive outside debt have a 24% higher probability of a successful IPO or sale compared to firms that obtain inside debt. A difference-in-difference estimator using the full sample provides similar results. Existing literature on underinvestment and asset substitution suggests that debt financing may cause incentive misalignment, which in turn may negatively affect firm outcomes. If that were the case here, firms that raise outside debt should have more severe incentive conflict than firms that

[4]Similar results hold with a simple IPO outcome variable.

obtain debt from insiders with equity stakes.[5] Hence, incentive misalignment is likely not the source of the observed relationship between debt and firm outcomes in entrepreneurial firms.

Our empirical results cannot be reconciled with traditional capital structure theories. This motivates a simple one-period model of security choice in venture capital-backed firms.[6] The model in the appendix builds on Hellmann (2006), who shows that the baseline optimal contract is an equity stake for the venture capitalist. The entrepreneur maximizes his utility net of his cost of effort that improves the firm's probability of success. The venture capitalist supplies capital at zero expected profit. At date zero, the firm may face an exogenous shock to firm quality (referred to as "external risks" by Kaplan and Strömberg (2004)[7]). After observing the shock, the entrepreneur and the venture capitalist negotiate a contract that includes equity and possibly debt.

If a firm faces a large adverse shock, an all-equity contract with lower equity values may not allow a venture capitalist to break even. If he tries to break even with a larger equity stake, the payoff of the entrepreneur may dip below his reservation utility. Debt in such instances allows the venture capitalist to receive interest payments in all states where the firm is solvent even if not extremely successful. The venture capitalist can now break even and provide financing without violating the reservation utility of the entrepreneur. Thus, debt is an endogenous response to reduced firm quality and a binding participation constraint rather than the cause of lower firm prospects. Last, the model also provides predictions connecting the source of debt and firm quality. To ensure non-negative return, outside investors will only provide debt if the borrowing firm's quality exceeds some threshold. On the other

[5]See for example, the Jiang, Li, and Shao (2010) study of dual-holder banks.

[6]Seminal theoretical works include Jensen and Meckling (1976), Ross (1977), Leland and Pyle (1977), and Myers and Majluf (1984).

[7]Example risks include changes to market size, competition, and exit market conditions. Both the venture capitalist and the entrepreneur have no prior knowledge of such risks.

hand, the insider investor will lend after an adverse shock because he has an existing equity position in the firm, which provides additional upside potential. The model's implications are consistent with our results.

Our work adds to the literature on entrepreneurial and private firm capital structure. Robb and Robinson (forthcoming) study the capital structure decisions of startups and find a surprising amount of formal debt at these startups' inception, highlighting a role of credit markets for startups. We differ by analyzing both the informative content of these decisions and their source in the VC market. Kaplan and Strömberg (2003) detail the contract choices of venture-backed firms, particularly the allocation of cash flow and control rights.[8] Green (1984) and Hellmann (2006) analyze the use of warrants and conversion features to align the incentives of financiers and managers in case of success. We argue that debt helps maintain incentive alignment in the face of adverse shocks to the firm. Kaplan and Strömberg (2004) analyze VC equity contracts and show that, in the cross-section, firms that face more external risks are more likely to have contracts with redemption rights, liquidation preferences, and other debt-like features. Our paper extends their analysis to the equity and debt decision over an entrepreneurial firm's lifecycle. Overall, by studying the choice of debt in a world where equity is the norm, we provide an alternative view on the determinants of financing choices of VC-backed firms.[9]

This paper contributes to the empirical literature that studies the positive relationship between leverage and firm value. For example, Masulis (1980) finds that stockholders benefit from leverage tax shield benefits. Asquith and Mullins (1986) show that new equity issues lower stock prices, while Vermaelen (1981) finds equity repurchases correlate with higher stock prices. A key feature of these environments

[8]Cumming (2005) looks at similar questions in a larger Canadian sample. Hellmann, Lindsey, and Puri (2008) study debt from outsiders and focus on how these capital providers build lending relationships with entrepreneurial firms.

[9]Rhodes-Kropf and Leamon (2009) present a case example of venture debt during the financial crisis and how venture capitalists can use debt to avoid pricing equity for a period of time.

is that debt has tax shield benefits or is a mechanism to signal firm quality to outside investors. The literature has also shown negative consequences of debt due to debt overhang or asset substitution. Chava and Roberts (2008) show that capital investment declines sharply following debt covenant violations. Giroud, Mueller, Stomper, and Westerkamp (2012) show that highly-leveraged firms suffer from debt overhang. Compared to these explanations, we argue that debt is an endogenous response to a reduction in firm quality where investors have in-depth knowledge of firm operations.

The relationship between firm financing and sources of capital based on information asymmetry is well documented, especially regarding bank financing. As insiders, banks can provide cheaper informed financing compared to costly uninformed arms length financing (e.g. James (1987)). Furthermore, Petersen and Rajan (1994), Berger and Udell (1995), and Bharath, Dahiya, Saunders, and Srinivasan (2011) show that the availability of bank financing increases if banks have closer ties with the firm. Jiang, Li, and Shao (2010) find that non-commercial banks that also hold equity in the firm provide cheaper debt. In our paper, insider VCs also provide debt to firms. However, we argue that VC-backed firms raise debt after an adverse shock. Entrepreneurial firms that obtain insider debt are of lower quality than firms that obtain outside debt.

Overall, we believe this paper makes the following contributions. To our knowledge, this study is the first analysis of debt in venture capital-backed firms. Using fixed effects, difference-in-difference, and cross-section estimators, we show that informative content of debt in venture capital contrasts with debt in public firms. Next, we exploit the variation in source of debt—inside and outside—to understand the mechanism that relates firm outcomes and debt. Last, our empirical results motivate a simple model of equity and debt choice in VC where debt is an endogenous response to adverse shocks to firm quality. We conclude that the information con-

veyed by capital structure choices of venture capital-backed firms depends on both the type and source of capital.

The paper proceeds as follows. Section 1 introduces the data and the basic features of debt finance. Section 2 presents a set of hypotheses for debt's informative content and the details of the model. Section 3 provides supporting empirical evidence. Section 4 discusses robustness tests and Section 5 concludes.

1 Data

1.1 Data Source

The main data source for our analysis is VentureSource, a comprehensive database of venture capital transactions that in our sample covers 1990–2010. VentureSource collects data on VC-backed companies using surveys of venture capitalists and entrepreneurial firms. VentureSource claims near perfect coverage of 1992 to the present for all entrepreneurial firms that received capital from a venture capitalist. Authors such as Cochrane (2005) and Hall and Woodward (2010) use a variant of VentureSource to study VC and entrepreneurial returns. VentureSource provides information about each financing round, including equity, debt, and exit (i.e. acquisitions and IPOs) events.

1.2 Data Description

We begin with a description of the data because, to the best of our knowledge, this is one of the first empirical studies of debt and equity choices in VC. VentureSource provides a classification of financings that separate equity and debt events. Debt events include straight non-convertible debt, credit, venture leasing (i.e. capital leases), and fully convertible bridge loans. Debt raised by venture capital-backed firms has sev-

eral important characteristics. First, entrepreneurial firms may borrow from firms that specialize in lending to VC-backed firms or from the venture capitalists who are already invested in the firm. Next, debt contracts can include warrant coverage of 7–10% of the principal. If another financing round follows debt, contracts often stipulate that the debt holders receive the full principal back and potentially redeem their warrants. Last, the interest rates on the debt typically range from 10–15% and have three to four year payment schedules.[10]

Table 1 provides the breakdown of debt financings for 1997–2010. We focus only on these debt types, as VentureSource's methodology in recording historical bridge loans has changed over time. We lack information on maturities, interest rates, and warrant coverage and focus instead on the debt event itself. Prior to 1997, debt was a less common feature of VC investments. Both venture leases and credit lines are a relatively small fraction of debt events, where straight debt dominates. Figure 2 presents the annual level of debt financing and its fraction of all dollars invested. Since 1997, debt accounts for over 5% of VC dollars invested per year at over $1 billion per year. Figure 3 displays the use of debt around two important events: the crash of the Nasdaq in 2000 and the Lehman Brothers bankruptcy in 2008. Both events resulted in a large increase in the use of debt finance. In particular, the marked fall in equity financings was not seen as strongly in debt financings. This supports our idea that debt may be an endogenous response to negative shocks in entrepreneurial firms.

We validate the coverage of debt financings in VentureSource in two ways. First, we check a random sample of 50 financings against regulatory filings (Form Ds) that according to VentureSource did and did not raise debt. We find no instances where debt was reported in the database and was not shown in the filings, nor where the filing reported debt and VentureSource lacked it. Second, a comparison of the cover-

[10]The Lerner (2000) case study discusses many of the typical features of venture debt.

age of non-convertible debt financings in VentureSource and VentureXpert—another leading source of VC financing information—shows the former has 50% more such events since 1997. This evidence suggests that VentureSource represents a comprehensive picture of the debt in VC.

1.3 Univariate Analysis: Debt vs. Equity

After cleaning the data,[11] we are left with 2,602 firms (11.7%) that ever received debt (15% since 1997). The typical entrepreneurial firm does not raise debt (i.e. debt to equity is zero), while the average debt to capital stock conditional on raising debt is 46.5% . Next, approximately 95% of debt financings occur after at least one equity event.[12] Some 60% of debt financings are followed by non-exit financings, with the remaining followed by sales, liquidations, or additional debt. Table 2 shows the types of financings that follow the debt events. Equity rounds such as "1st" and "3rd" account for over half, while the remaining are either additional debt financings or exit events, such as acquisitions. In summary, debt financings typically occur between two equity financing events.

Table 3 summarizes the financing-level differences of equity and debt financings.[13] The average amount borrowed is $7 m, which compares to an average equity investment of $10.9 m. The "Difference" column shows the difference between the two financing types and makes clear that there are few dimensions of similarity. "Log pre-money", a key measure in this paper, is the firm equity valuation prior to the

[11] We exclude firms whose only financing is a debt round because their capital structure is degenerate. We remove six firms that raised over $100m in debt as over 70% of all their capital raised came from large PE or hedge funds.

[12] This is not to say the firms do not have smaller formal sources of debt at founding; however, those are likely very small compared to initial equity financing because they would otherwise appear in regulatory filings.

[13] This is for the subset of events with a known or imputed valuation in the previous financing. We exclude exit events such as acquisitions or IPOs. See Section 1.5 for a discussion of imputation methodology.

capital investment. Compared to equity events, debt financings occur later in a firm's life, follow higher valuations, occur in financings when the firm is profitable, and occur more quickly since the previous financing. Such a selection of firms likely have lower growth options, so according to Myers (1977), they have a higher probability of having debt. The final variable "Capital raised $t+1$/ capital raised t" represents the relative increase in capital raised between the current and subsequent financing. Debt financings are followed by much larger ramp-ups in capital invested than equity rounds (5.5 vs. 2). This fact shows debt can easily be repaid in subsequent financings and agrees with case study findings that detail the typical structure of debt contracts concerning principal repayment in post-debt financings.

Next, we investigate the characteristics of firms that take debt and those that do not. Table 4 presents firm-level characteristics for the two groups. The "Difference Test" column provides the t-test for differences, where a negative difference implies firms that never raise debt have a larger value of the variable. Several differences stand out. Firms that raise debt at some point in their lifecycle are more likely to be older as proxied by the number of financings, based outside California, in the biotechnology industry and are likely to remain private longer. Overall, it is clear from Tables 3 and 4 that entrepreneurial firms that raise debt are different across a variety of dimensions. The empirical analysis below will control for these differences.

1.4 Univariate Analysis: Inside vs. Outside Debt

VentureSource also provides a list of investors in each financing round. For a financing event at time t, we can identify all existing equity holders who we refer to as inside investors.[14] An "inside" debt round is a round where all the investors (i.e. lenders)

[14]Secondary transactions where existing investors can sell their equity stakes are rare and if they occur, the investor sells a fraction of their stake.

have already invested in previous equity rounds.[15] An outside debt round has at least one new investor that could be a venture lenders or a standard VC firm. Approximately 11% of the debt financings are missing any investor information, while less than 5% of equity financings lack any investor information. We assume that debt rounds without an investor are outside debt.[16] Outside debt accounts for 45% of the debt financings and 58% of the debt dollars since 1997.

Table 5 shows the results of a univariate analysis and details the differences between inside and outside debt. Debt lent by insiders is smaller, occurs later in a firm's life, and raises less capital than debt provided by outsiders. In unreported regressions, we analyze the characteristics of firms that predict the choice of inside debt over outside debt with a probit regression of entrepreneurial firm characteristics at the time of the first debt financing. Using the set of 2,008 debt financings, we find that total capital raised, number of unique syndicate members, and whether the syndicate has a top quartile venture capitalist[17] each predict a higher probability of outside debt. The results are robust to controls for average VC syndicate member experience and are obtained after fixed effects for year, round number, and entrepreneurial industry. Insofar as these variables proxy for entrepreneurial firm quality, syndicate quality, and success rate, it appears that outside lenders lend to ex-ante better entrepreneurial firms than those that insiders finance.

1.5 Firm Valuation

The major variables of interest in VentureSource are types of financing (equity, debt, or exit), financing date, amount invested, and valuation. Valuations for equity and

[15] VentureSource's classification shows that not all these financings are fully convertible debt.
[16] The results are similar if we assign them as inside debt rounds.
[17] A VC investor that was in the top quartile of total dollars invested in the previous year.

exit financings in VentureSource are sometimes missing.[18] The literature has settled on two approaches in addressing the missing valuations: modeling the selection and imputation. Cochrane (2005) and Korteweg and Sorensen (2010) use the former method with parametric models of the financing and valuation process. Using data on private equity exit transactions, Bernstein, Lerner, Sorensen, and Strömberg (2010) use imputation to study the impact of private equity across countries. In this paper we use the Hall and Woodward (2010) methodology to impute missing equity (non-exit) valuations. Hall and Woodward (2010) use a large, representative database of over 1,000 VC financings with full and correct information to estimate an imputation model that connects valuation to financing sequence number and dollars invested.[19] The authors compare imputed valuations to those reported and find no significant bias. We apply the procedure for approximately 51% of the financings. All major results below are qualitatively robust to excluding the observations with missing valuations, as the estimated bias in the imputed valuations is zero.[20]

As an additional check of the imputation method, we compare the predicted valuations from the imputation approach to true valuations using a set of 313 financings provided by several large VC firms.[21] A regression analysis with controls such as industry, year, and firm region independently confirms the approach introduces no significant bias. Both the mean and median prediction error are zero for this set of observations. Furthermore, a comparison of the reported valuations in VentureSource to the predicted valuations also shows no significant bias. Thus, we are confident in using the Hall and Woodward (2010) imputation methodology.

[18]Kaplan, Sensoy, and Stromberg (2002) find that VentureSource "provide[s] unbiased, but noisy measures of financing amounts and their valuations" (if reported).

[19]See the Appendix in Hall and Woodward (2010) for details.

[20]The lack of imputed values generally creates a sample size issue.

[21]We thank Correlation Ventures for access to this anonymized data.

2 Hypothesis Development

The capital structure literature provides clear predictions about this paper's major questions: does choice of debt over equity convey any information about entrepreneurial firm prospects, and does the source of financing matter?

The first set of theories provide what we call "positive selection" hypotheses. Ross (1977) and Myers (1977) show that a firm's issuance of debt (versus equity) signals better future prospects. Masulis (1980), Masulis and Korwar (1986) and Vermaelen (1981), among others, find empirical evidence supporting this conclusion. By increasing or decreasing leverage, managers signal to uninformed outside investors that the firms equity is under or over valued respectively. Leverage may also have negative implications for firm prospects through a "treatment" effect. In the case of debt overhang (Myers (1977)), excessive leverage leads to under-investment because bondholders earn a larger fraction of gains.[22] Asset substitution (Jensen and Meckling (1976)) leads managers and equity holders to take on excessive risk as debt holders bear the downside. Both result in debt as a negative signal for firm prospects. The paper's first set of empirical analyses tests whether the choice of debt in entrepreneurial firms is associated with positive or negative changes to firm prospects.

The source of both debt overhang and asset substitution problems is the incentive conflict between equity and debt holders. The variation in the sources of debt in VC provide a unique way to test whether such incentive misalignments explain our findings. Outside lenders do not have an equity position, so they should face more incentive conflicts with equity holders than insiders (i.e. those who have both equity and debt). Thus, if debt causes any observed negative relationship between leverage and firm value, the existence of an outsider implies a larger negative impact on firm

[22]Giroud, Mueller, Stomper, and Westerkamp (2012), for example, find causal evidence of a negative impact of excessive leverage.

valuation. However, the empirical analysis below shows the opposite: debt provided by outsiders signals relatively *better* quality firms and firm prospects than inside debt. Thus, we require an explanation for debt as a negative signal that can also explain why outside debt signals higher firm quality. In contrast to the existing theories above, we require a "negative selection" mechanism for the debt and equity choice. The Appendix provides such a model where debt is an endogenous response to an adverse shock to firm quality. The intuition is as follows.

Consider an entrepreneur with an idea, who due to lack of capital, approaches a venture capitalist. The entrepreneur expends costly effort that affects firm prospects. The venture capitalist operates at zero expected profits. Motivated by existing theory (Hellmann (2006)) and the fact that our data show 95% of initial VC financings are equity, we assume the benchmark contract is equity financing. If the firm faces a sufficiently large adverse shock to firm quality, then in some cases an all-equity contract is infeasible.[23] Infeasibility here occurs either when the VC does not break even on provided financing or when the contract results in a payoff that does not exceed the entrepreneur's reservation utility. Debt provides a feasible alternative.

Debt provided by the VC allows the project to continue and also allows the entrepreneur to retain a sufficient equity stake. The VC trades off the upside gains from equity with the interest payments of debt. However, the choice of debt over equity signals that the firm suffered an adverse shock and that firm value has fallen. Furthermore, an inside VC is willing to lend after an adverse shock even when an outside VC is not. This is because an inside VC has an existing equity position in the firm, which provides a positive return if the firm continues. The outsider, on the other hand, is only concerned with the return on debt financing. Thus, in contrast to an incentive misalignment mechanism, we argue that debt from insiders signals

[23]These shocks mimic the external risks in Kaplan and Strömberg (2004). Such risks include changes to market size and competition. Both the VC and the entrepreneur have no previous knowledge of such risks.

worse prospects that debt lent by outsiders. The framework provides the following empirical implications.

Testable Implication i *If a firm finances using debt, then the project's quality must be worse than previously expected by inside parties. Hence, firm value should fall after debt financing.*

Testable Implication ii *When a firm with debt in its past approaches outside investors for an IPO or acquisition, its value and future prospects are deemed lower than those of a comparable firm without debt in its past.*

Testable Implication iii *Outside venture capital providers provide debt to better quality firms than inside venture capitalists. The decline in quality is also less pronounced when an outside venture capitalist provides financing.*

The Appendix provides the assumptions and details of the model.

3 Empirical Evidence

We now study the relationship between the choice and source of debt and firm outcomes with fixed effect, difference-in-difference and cross-section estimators.

3.1 Within-firm Relationship Between Debt and Valuation

Implication (i) says that debt financing precedes falls in firm quality as a result of its endogenous response to an adverse shock. Any changes in quality should result in a decline in growth and valuation. We use our panel of entrepreneurial firm capital structure choices and valuations to test this hypothesis. Consider first the set of all firms that ever raised debt and their financing-by-financing equity valuation or

growth in value. The following specification captures the within-firm relationship between debt and valuation:

$$V_{it} = \beta_0 + \sum_{k=-3,k\neq-1}^{4} \rho_k F_{i,k} + \gamma_t + \alpha_i + \beta_1 Z_{it} + \epsilon_{i,t}. \quad (1)$$

The unit of observation is the financing event of the entrepreneurial firm i, where V_{it} is a measure of firm quality at time t, α_i is the firm fixed effect, ρ_t are year fixed effects, and $Z_{i,t}$ is a series of time-varying firm and market characteristics. $F_{i,k}$ is an indicator variable for each equity financing round $k \in [-3, 4], k \neq -1$ with respect to the debt event. The indicator for the pre-debt equity financing round is excluded since it serves as the reference point. Thus, coefficient estimates of ρ_k on $F_{i,k}$ capture within-firm changes in the dependent variable around debt financing. This dependent variable is either the growth in firm valuation between financings defined by $\text{Pre\$}_{i,t}/\text{Post\$}_{i,t-1}$ or the log of pre-money valuation in the current financing.[24]

Table 6 shows the estimates of Eq. (1) where columns (1)–(3) use the log pre-money valuation as the dependent variable. The remaining columns use the growth in firm valuation between financings. We exclude the coefficient estimates on the set of controls that include log firm age, total capital stock, the financing sequence, annual return on the Wilshire 5000, and years since previous financing. Estimates in columns (1) and (4) show there is no strong relationship between firm value growth or level before the debt event. However, immediately after debt financing, firms exhibit a statistically and economically significant reduction in both firm value and growth rate. Figure 1 presents the post-debt decline in log valuation implied by the coefficient estimates $\hat{\rho}_k$ from column (2) of Table 6. The figure shows a hypothetical baseline of 100 at the excluded pre-debt financing. The magnitudes are significant: the coefficient on the financing dummy three financings after debt implies a decline

[24] Again, pre-money valuation is the firm equity valuation prior to the capital investment.

of 40% in firm value. The "No defaults" columns exclude firms that failed after their debt financing, while the "No exits" columns exclude those that had an exit immediately after. Both sub-samples address concerns that very large or small exit valuations drive results. The estimates are consistent across all specifications.

We also estimate the average reduction in equity valuation after debt financing. To do this, we estimate the coefficient to the indicator variable "After Debt$_{i,t}$", which is equal to one if the firm was financed using debt prior to period t. After Debt$_{i,t}$ is one when $F_{i,k}$ from Eq. (1) is one for any k greater than zero.

$$V_{i,t} = \alpha_i + \beta \text{After Debt}_{i,t} + \gamma Z_{i,t} + \rho_t + \nu_{i,t} \tag{2}$$

In the above, the variables are as in Eq. (1), and $\nu_{i,t}$ is the error term. The empirical prediction (i) suggests the presence of debt in an entrepreneurial firm's financing history conveys negative information regarding firm quality. Hence, we expect estimated coefficient $\hat{\beta} < 0$. The fixed effects estimates from Eqs. (1) and (2) control for any time-invariant differences between firms that issue debt, such as industry, VC quality, or location. As a robustness check, we also estimate a specification similar to Eq. (2) using a continuous variable of debt "Debt/Last Equity" which is the ratio of amount borrowed to last equity amount raised.

Table 7 presents the estimates from Eq. (2) where the dependent variable is the log firm valuation.[25] The independent variable of interest is the indicator that a debt financing occurred in the past. Again, the sample includes any firms that ever raised debt and had at least one post-debt equity event (exits included). The variables "Profitable" and "Positive revenue" are mutually exclusive binary variables. "Positive revenue" denotes firms that have positive revenue but are not profitable yet. The "1 year Wilshire" return attempts to control for time-varying market risk that

[25]Results are similar to post-money valuations.

can affect entrepreneurial firm valuations. The control for financing sequence (i.e. log round number) and age attempt to address the within-firm trend in valuation.[26] The fixed effects estimate of -0.52 for $\hat{\beta}$ in column (1) implies that post-money valuations fall by approximately 40% over all post-debt equity financings. Columns (2) and (3) show results after excluding firms that failed immediately after a debt round and firms where first post-debt financing was an acquisition or IPO ("No exits"). The results are similar to those in column (1). This evidence suggests that defaults (i.e. zero post-debt equity values) and other causes of exit immediately after debt are not driving our findings. The last column in Table 7 replaces the indicator variable for "After debt" with a continuous debt as a fraction of capital raised in the last equity round. The relationship remains intact in this case.

The estimation technique in each of these cases ensures that identification of impact of debt financing is accomplished purely based on within-firm changes between equity financings. It is consistent with investors financing a firm through debt after an adverse shock to the firm (Implication (i)).

Firms With and Without Debt: Difference-in-difference

The fixed effects estimation in Tables 6 and 7 exploits within-firm valuation changes around the debt financing to identify the coefficients of interest. The sample only includes entrepreneurial firms that have raised debt. Consider the following difference-in-difference specification that incorporates all firms:[27]

$$V_{i,t} = \beta_0 + \sum_{k=-4}^{4} \theta_k D_{i,t+k} + \beta_1 Z_{i,t} + \gamma_t + I_i + \nu_{i,t}. \tag{3}$$

As in Eq. (1), this model uses event time indicators around debt financing D_{t+k}, where $D_{i,t+k}$ is 1 for the financing event of a firm that borrows k financings from

[26] Specification 1 includes identical controls.

[27] The estimation approach follows that of Jiang, Li, and Shao (2010).

the debt round. Here, γ_t is a financing year fixed effect and I_i is an industry fixed effect.[28] Controls Z_{it} include firm capital stock, age, financing stage, and years since previous financing. The coefficient θ_k represents the average difference in the valuation of firms that raise debt, k periods after (or before) debt financing, relative to firms that instead raised equity financing in the same year and industry. For example, a negative θ_2 suggests the average valuation that follows two rounds after debt financing is smaller than those of firms in the same industry that raised equity the same year. Implication (i) says that $\hat{\theta}_k < 0$ for some $k \geq 1$.

Before presenting the results, consider the interpretation of the difference $\theta_k - \theta_{-1}$, where $k > 0$. This value measures the change in relative valuation for firms that borrow k periods after a debt financing. A negative value implies that firm value—relative to the firms financed without debt in the same year and industry—has fallen after the borrowing event. Thus, our hypotheses predict a negative value for these difference-in-difference estimates.

Table 8 presents the results for the full sample (Panel A), all firms excluding exit financings (Panel B), and non-exit financings of firms that did not fail (Panel C). We focus on Panel A as the results are robust across sub-samples. Reported coefficients θ_k estimate the average difference in valuations of firms that obtain debt with respect to firms in the same industry that obtained equity that year. Consistent with our hypotheses, firms that obtained debt have lower valuations after debt financing with respect to firms that obtained equity financing. Estimated coefficients are statistically significant and economically meaningful with θ_1 of -.089, suggesting a -8.5% difference in valuation. The difference-in-difference estimates for $k \in [1, 4]$ show there is both a statistically and economically significant deterioration in valuation for firms after obtaining debt financing. Intuitively, the estimates say that

[28] The equation does not have a dummy variable for any debt financing in a firm's lifecycle. Hence, θ_k estimates capture the average effect.

that relative difference in valuation between firms that raise debt and those that raise equity flips from positive to significantly negative. The results are consistent with the fixed effect panel estimates and indicate that firm valuation falls after debt financing whether we look within firm or between firms.

3.2 Debt Finance and Cross-sectional Outcomes

In this section, we ask if VC debt is a negative signal for entrepreneurial prospects as measured by successful exit opportunities, such as an IPO or sale to another firm. If debt events follow adverse shocks to firm quality, then their presence should reduce the ability of an entrepreneurial firm to have a successful exit (Implication (ii)).

We employ three measures of firm prospects. A popular measure of success for entrepreneurial firms is whether such firms are able to have a successful IPO. Another measure of success is if a firm is successful in being acquired—defined as cases in which reported exit values exceed twice the capital raised by the firm. As our first measure of firm prospects, we create an indicator variable that is one in case of either of these outcomes.[29] Our second measure is the total value created at exit after controlling for capital raised, which proxies return for investors (zero if failure). Last, we identify those entrepreneurial firms that had a CEO change in their history. We expect that firms that suffered negative shocks are also more likely to have a CEO change and thus use such a change as our final measure. All regressions include the variable "Had debt round" which is equal to one if the entrepreneurial firm ever raised debt and includes controls for industry, year founded, region fixed effects, total capital raised (i.e. size), and age. The sample includes only entrepreneurial firms founded prior to 2006 to allow firms time for an exit event by the end of the

[29]The results are robust to using simple acquisition; however, many acquisitions lacking exit valuations may be disguised failures. For clarity, we focus on the more accurate success measure.

sample period.[30]

Table 9 shows the results of the cross-sectional analysis. Unreported marginal effects suggest that a debt round is associated with an approximately 26% lower probability of an IPO or successful acquisition outcome (compared to the mean likelihood of 23%).[31] Firms that raise debt have 23% lower exit values and have 12% more CEO changes. Columns (4)–(6) attempt to isolate the intensive margin of debt financing with the use of "Debt / Last equity," a continuous measure of the amount of debt. The results are robust to the inclusion of the variable, which is identified by the variation from the mean amount of debt. These results suggest that while the presence of debt signals a relatively worse firm, those firms that can obtain more debt capital from venture capitalists have high exit valuations and success rates. This is intuitive because debt financing may be a choice, but capital needs are firm-dependent. Together, these results support Implication (ii) and show that debt in the entrepreneurial capital structure is meaningful for both within-firm valuation and final outcomes.

3.3 Inside Versus Outside Debt

In this section, we test Implication (iii) prediction that venture capitalists who do not have an equity stake (outsiders) provide debt to relatively better quality firms than insiders and any falls in post-debt valuation are less severe. This test also allows us to distinguish our mechanism from a channel where firm prospects suffer due to misaligned incentives between an entrepreneur and the venture capitalist debt provider. By construction, outside lenders face relatively more incentive conflicts with equity holders than insiders providing debt. Such incentive conflicts lead to deterioration in firm prospects and thus, according to these models, outside debt

[30]The results are qualitatively similar using the full sample as well.

[31]The results are qualitatively similar if we use only IPO as a successful outcome.

financings should result in relatively worse firm outcomes.

Fixed Effects, Valuation, and the Source of Debt

Table 10 reports the results of a panel estimation similar to that in Section 3.1, with the debt event separated by those financed by inside or outside investors.[32] Comparing the estimated coefficient of the "After debt" indicator between the two samples across all specifications in Table 10, outside debt exhibits significantly smaller drops in future equity values. Firms that obtain inside debt suffer from a fall of 58% in value, while those obtaining outside debt only suffer from a 37% fall in value. The estimates indicate that firms that obtain debt from outside investors have approximately a 21% lower fall in equity values. All differences are statistically significant at the 1% level. The estimates show that outside investors lend to better firms or that inside investors are willing to lend to marginally worse firms and such differences manifest themselves in larger falls in valuation for inside debt (Implication (iii)).

Difference-in-difference and Source of Debt

In this section, we perform a difference-in-difference estimation similar to that in Section 3.1, where the variable of interest is the debt *source* event time:

$$V_{it} = \beta_0 + \sum_{k=-4}^{4} \theta_k^I \mathrm{In}_{t+k} + \sum_{k=-4}^{4} \theta_k^O \mathrm{Out}_{t+k} + \beta_1 Z_{it} + \gamma_t + I_i + \nu_{it}. \tag{4}$$

The variables In_{t+k} and Out_{t+k} are dummies for inside and outside debt financings that are similar to D_{t+k} in Eq. (3). Table 11 presents the results. The first pattern is the estimates of θ_k^1 for the inside debt financings. Here, the pre-debt estimates are insignificant and only turn negative after debt, suggesting the higher pre-debt valuations found in Table 8 likely stem from outside debt financings. The difference-

[32]The fixed effect specification limits our ability to use an interaction.

in-difference estimates $\hat{\theta}^I_K - \hat{\theta}^I_{-1}$ show that after obtaining debt, the valuations fall in multiple rounds after inside debt financing. Similar patterns hold for the same difference-in-difference for outside debt $\hat{\theta}^O_K - \hat{\theta}^O_{-1}$, providing additional evidence for the post-debt valuation fall predicted by Implication (i). The significant differences throughout the last row of Table 8 are also consistent with Implication (iii), which states that outside lenders lend to better firms (i.e. higher valuation) than inside lenders. For example, the estimate of $\hat{\theta}^I_2 - \hat{\theta}^O_2$ of -.38 says post-inside debt financings at $k = 2$ have 15% lower equity valuations than post-outside debt financings.

Cross-Section and Outside Debt

In this section, we study the relationship between the source of debt and measures of firm outcomes such as the ability to have a successful exit, exit valuation, and CEO tenure. Among a sample of firms that have all obtained debt, we use an indicator variable "Outside debt" to distinguish firms that obtain debt from a non-equity holder.

Table 12 shows the results. Column (1) results show that among the firms that obtain debt, firms that have obtained debt from outside investors have a 24% higher probability of success (IPO/acquisition) and have higher exit valuations. While Table 9 showed that the presence of debt financing from any source increases the probability of a CEO change, column (3) of Table 12 shows no additional difference in the propensity of CEO changes based on the source of debt.

The final three columns of Table 12 ask whether the intensive margin of outside lenders has any additional explanatory power. The variable "% outside investors" is the fraction of outside investors in the debt financing. The results suggest the presence of at least one outside debt provider (i.e. the extensive margin) is sufficient to explain cross-sectional differences by source of debt. In unreported results, we

find that firms that raise outside debt are also significantly less likely to default.

Overall, the evidence from both the panel and cross-sectional analysis is consistent with Implication (iii)'s predictions concerning the source of debt and entrepreneurial firm outcomes.

4 Robustness Tests

4.1 Imputation and Selection

The estimations thus far all employ the imputation methodology of Hall and Woodward (2010) to address missing valuations in the data. Table 13 repeats the analysis in Table 7 without imputed valuations and shows similar conclusions. The mean dependent variable is 10% larger for the non-imputed sample, and the sample of firms is almost halved. Nonetheless, our results remain similar in direction and magnitude. Firms suffer statistically and economically significant reductions in valuation after debt. Thus, following the imputation methodology of Hall and Woodward (2010) is not affecting our findings.

Bernstein, Lerner, Sorensen, and Strömberg (2010) also use an imputation methodology for their study of private equity transactions and economic growth. They focus on quartiles of the imputed value distribution for their analyses.[33] As an additional robustness test of the imputation methodology, we re-estimate the major specifications with entrepreneurial firm valuations by winsorizing the tail-end imputed values aggressively. In particular, we re-estimate the specification in Table 7 with imputed valuations outside the top or bottom 5% tail of the known and imputed valuation distribution. The results remain similar, with or without winsorization, so we conclude that the imputation methodology is not driving our empirical results.

[33] In contrast to our study, they had imputed valuations as control variables.

As an alternative robustness test without imputation, we follow Korteweg and Sorensen (2010). Firms with IPOs have a higher fraction of reported valuations, which the authors correct with a re-weighting mechanism based on true exit type fractions. In unreported results, we re-estimate the main specification (Table 7) using the historical fraction of exit types (failures, acquisitions, and IPOs) as sampling weights. The results remain robust to this test. Overall, we conclude that the imputed valuations are not driving the results.

4.2 Placebo Test

In unreported results, we conduct a placebo test to further address any selection bias in our estimation procedure. All firms are randomly treated with the "After debt" variable at some point in their lifecycle. We obtain a positive coefficient estimate for this random "After debt" variable, which is intuitive given survivorship bias; a firm's valuation grows over its lifecycle and if it falls significantly, it leaves the sample. This suggests our null hypothesis could be positive, and a null of 0 that we use in our estimation is conservative. Estimates that break down estimates by rounds show that, as expected in the placebo test, there is no negative effect on firm valuation after debt. If anything, as before, the coefficients are positive.

Next, we estimate the impact of debt using the actual sample of firms that obtain debt and assign random debt treatment to the firms that never obtained debt. Again, we find that only the firms that actually had debt (not the placebo firms) suffer from a large negative reduction in firm equity valuation. We conclude the results are robust to the specification of the "After debt" variable.

4.3 Concurrent Debt and Equity

We next focus on debt financings that occur on the same date or within a month to another equity financing. Nearly 25% of the debt financings observed in the data satisfy this restriction. In such cases, the venture capitalist finances the firm through a combination of debt and equity, compared to only debt.

Our mechanism suggests the adverse shocks in this case must have been smaller for the venture capitalist given that the venture capitalist did not make a complete switch. Hence, the negative relationship between debt and future firm prospects should be weaker (Implication (i)). To test this hypothesis, in unreported results, we repeat the analysis in Table 7 for the subset of firms that raise debt and equity within a month. Equity valuations after debt financing fall 42% less for firms that obtain debt and equity within a month compared to the full sample of firms. In a cross-sectional analysis, firms that raise debt and equity in close succession have larger exit valuations than other firms that only obtain debt. These empirical patterns further support the underlying economic mechanism proposed in this work.

4.4 Additional Robustness

Bridge rounds are non-equity financings provided by inside investors to firms. Due to inconsistencies in the identification of such rounds in the data pre-2002, we exclude them from the sample of debt rounds. However, the classification criteria are consistent from 2002. To address any concerns regarding the exclusion of these financings from our analysis, in unreported regressions, we repeat the main regressions by including them. We find the original results remain robust to the inclusion of bridge rounds as debt events.

The major conclusion also remains unchanged when we restrict the sample to firms in sectors without observable assets to recover, such as those without patents

or non-tangible asset-based industries. The relationship between debt and falls in future valuations remains robust to this sub-sampling, alleviating concerns that the presence of collateral may be driving the choice of debt. Furthermore, we repeat the analysis for firms that raise less capital in the post-debt equity event than the total capital raised in the debt round. Such firms may not be able to pay back the principal in the immediate successive round. The results remain robust to this sub-sample analysis.

Finally, the major empirical patterns are robust to particular time periods and the investor characteristics. First, excluding the financial crisis of 2008–2009 has no impact on our conclusions. Second, introducing VC investor fixed effects to the major specifications does not alter estimates, suggesting idiosyncratic investor characteristics do not drive the relationship between debt choice and valuation.[34] Overall, our findings show the negative relationship between debt financing and equity valuation is robust to a large set of alternative explanations.

5 Conclusion

We study the information conveyed by the capital structure choices of VC-backed firms. Research about this relatively unexplored topic provides a unique perspective of the financing decisions of firms. Using a novel panel dataset of VC financings, we find that debt financing implies lower firm quality. This change in firm quality leads to a 40% lower equity valuation and ultimately 26% lower success probability. We find that relatively better quality firms obtain debt from outsiders who do not have an equity stake. The empirical results hold across various estimation procedures that include fixed effects, difference-in-difference, and cross-sectional analysis. The results are robust to sub-sample analyses and various controls at the firm and investor levels.

[34]These specifications only work in the difference-in-difference and cross-section specifications.

The unique environment of entrepreneurial firms—where venture capitalist investors do not suffer from severe information asymmetry and jointly determine financing contracts with the entrepreneur—provides new insights into the choice of debt financing for firms. Debt financing may not convey positive information about a firm. Furthermore, the source of financing may be crucial in interpreting the information conveyed by capital structure choices. The results cannot be reconciled with existing theories in which debt causes negative firm outcomes (i.e. debt overhang or asset substitution). Hence, we propose that debt is an endogenous response to adverse shocks, where it acts as an alternative financing mechanism to maintain incentive alignment.

Overall, these results contribute to the literature on venture capital contracting (e.g. Hellmann (2006) and Kaplan and Strömberg (2004)) and entrepreneurial capital structure (e.g. Robb and Robinson (forthcoming)), while demonstrating how financing decisions can differ in the absence of information asymmetry and typical benefits of debt finance.

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Appendix

A A Simple Model

We provide an economic model in which debt is a response to negative shocks to VC-backed firms. The model borrows from the setup of Hellmann (2006) - who provides a new explanation for the use of convertible securities in venture capital. The optimal contract gives the venture capitalist more cash flow rights in acquisitions than IPOs through the use of convertible bonds. In contrast, in this paper, we ask under what circumstances straight debt has a role in the financing of venture-backed firms. We present a model that shows that the switch to debt from equity can be a response to lower firm prospects in the future.

A.1 Setup

An entrepreneur with no capital has a project idea that only he can execute. The project needs a total financing commitment of x from a risk-neutral venture capitalist, with $x - d$ already committed before time starts. At time 0, the firm may receive a shock $\epsilon \in [-\bar{\epsilon}, \bar{\epsilon}]$, where the shock has a bounded support $0 < \bar{\epsilon} < \infty$ and $\mathbb{E}\epsilon = 0$. After observing the shock, the parties enter a contract and the venture capitalist provides additional capital d. The project outcome is realized at time 1. The entrepreneur has a reservation utility of $\underline{u}$. If his reservation utility is not met in any state of the world, he abandons the project and all invested capital is lost.

Let $\omega = \sigma s_E$ denote the probability of the success of the project. σ is positive and exogenous and s_E is the effort of the entrepreneur and is non-negative. If successful, the firm is valued at v. For notational convenience, let $\pi \equiv \sigma v$. The possible outcomes for the entrepreneurial firm are detailed in Figure 4.

The shocks to firm success resulting from ϵ may be envisioned in the spirit of "external risks" detailed in Kaplan and Strömberg (2004). Such risks include changes in market size, competition, and macroeconomic conditions. There is symmetric uncertainty about these risks since neither entrepreneurs nor VCs have prior information regarding such shocks.

A.2 Incentives

For simplicity, we assume quadratic cost of effort $\frac{1}{2}c_E s_E^2$, where parameter c_E measures the disutility of labor. The venture capitalist only provides capital and operates on zero profit due to perfect competition among capital suppliers. The venture capitalist finances $x - d$ with equity before time starts and reserves the right to provide financing d at time 0 using either equity or debt.[35] If the firm is financed with all equity, then the stake of the venture capitalist is e in the firm. However, if the second round is financed with debt d, then the equity contract is also renegotiated to e'. We will solve for these terms shortly.

As the benchmark case, let us assume there was no shock and the venture capitalist's cash flow rights provide him equity stake e in the firm. Both the literature and practice motivate our choice of equity for initial financing.[36] Let u_E and u_V denote the expected utility of the entrepreneur and venture capitalist, respectively, net of invested capital x:

$$\begin{aligned} u_E &= s_E(1-e)\pi - \frac{1}{2}c_E s_E^2 \\ u_V &= s_E e\pi - x \end{aligned} \tag{5}$$

The venture capitalist has stake e in the firm that allows the VC to break even if $e = \frac{x}{s_E \pi}$. Substituting e, required by the venture capitalist, into the utility of the entrepreneur obtains $u_E = s_E(1 - \frac{x}{s_E \pi})\pi - \frac{1}{2}c_E s_E^2$. The first order condition yields the effort s_E entrepreneur E chooses to maximize his utility, $s_E^* = \pi / c_E$. Intuitively, the entrepreneur maintains a constant effort, s_E^*, which depends on the expected value of firm π and which is inversely related to the disutility of effort c_E.

So far, we have assumed the effort of the entrepreneur ensures his utility is above reservation utility $\underline{u}$. This is true as long as π, and in turn σ, is above a certain level.

Proposition A.1 *The constrained maximized utility of the entrepreneur, given op-*

[35] This simplification abstracts away from various additional features of contracts in VC literature (see Kaplan and Strömberg (2004)). We find this acceptable since we are only interested in explaining the circumstances under which firms switch to debt financing. The intuition of switching to debt also carries through for debt-like instruments such as senior equity or liquidation preference greater than 1.

[36] Myers (1977) shows that growth firms prefer equity financing, while Hellmann (2006) shows that cash flow rights of venture capitalists can be optimal if the firm is expected to be successful. In our data, some 85% of financing is equity. Showing that an all equity contract is optimal is beyond the scope of this work.

timal effort s_E^*, needs to satisfy the following individual rationality (IR) constraint:

$$u_E = \frac{\pi^2}{2c_E} - x \geq \underline{u}. \tag{6}$$

Proof: Using the break-even condition of the venture capitalist, $e = \frac{x}{s_E \pi}$, we obtain $u_E = s_E(1 - \frac{x}{s_E \pi})\pi - \frac{1}{2}c_E s_E^2$. Then, using the optimal effort relation, $s_E^* = \frac{\pi}{c_E}$, we obtain $u_E = \frac{\pi}{c_E}(1 - \frac{x c_E}{\pi^2})\pi - \frac{c_E \pi^2}{2c_E^2}$, which ultimately yields the IR constraint.

Intuitively, the payoff of the firm net of investment and cost of effort of the entrepreneur at optimal effort must be greater than the reservation utility of the entrepreneur. Rearranging the terms from the above proposition yields the following corollary.

Corollary A.2 *In order to ensure an all equity contract is feasible, the following condition is necessary:*

$$\sigma \geq \frac{1}{v}\sqrt{2c_E(\underline{u} + x)}. \tag{7}$$

Simply put, an all-equity contract and its equity stake that satisfies both the IR constraint and the VC break-even condition fails for large enough negative shocks to σ.

A.3 Contracting under New Information

Suppose now that the firm faces a shock ϵ so that the exogenous parameter on the probability of success is now $\sigma' = \sigma - \epsilon$.[37]. The case of interest with respect to this work is when the magnitude of the shock is sufficiently large and negative such that $\epsilon > \sigma - \frac{1}{v}\sqrt{2c_E(\underline{u} + x)}$ (Eq. 7). In this case, an all equity financing is infeasible since it violates the IR constraint of the entrepreneur. Here, one alternative is to shut down the firm and lose invested capital.

Debt provides another alternative. The venture capitalist provides debt d and the remaining needed capital $x - d$ for an equity stake e' in the firm at the break even condition, while also ensuring the entrepreneur is above his IR constraint. The venture capitalist lends money at interest rate r and is able to recover invested capital with probability λ.[38] r is endogenous to the recovery rate. For simplicity, let us

[37] Given the probability of success is positive, the biggest negative shock $\bar{\epsilon}$ cannot be greater than $-\sigma$. Thus, $\sigma - \epsilon > 0$.

[38] In practice, venture capitalists are able to recover invested capital in some cases by liquidating the firm, even if the firm is not successful. Thus, $\lambda > \omega$.

assume the venture capitalist breaks even on debt financing, such that $\lambda(1+r)=1$, and hence $r = 1/\lambda - 1$. Let $\pi' \equiv \sigma' v$ and s'_E denote the effort expended by the entrepreneur in this case. The expected utilities of the entrepreneur and venture capitalist are now given by:

$$\begin{aligned} u'_E &= s'_E(1-e')\pi' - \frac{1}{2}c_E {s'_E}^2 - dr \\ u'_V &= \underbrace{s'_E e'\pi' - (x-d)}_{\text{Return on equity}} + \underbrace{\lambda(1+r)d - d}_{\text{Return on debt}}. \end{aligned} \tag{8}$$

Compared to Eq. (5), the entrepreneur's utility is now net of the interest payment on debt, and the venture capitalist's payoff now includes return on debt.

The following proposition characterizes the amount of debt financing required for the firm to continue after a large negative shock.

Proposition A.3 *Conditional on feasible debt financing, the downward adjustment of the probability of success of the firm ϵ and level of debt d are positively related where d is:*[39]

$$d = x - \frac{\pi'^2 e'}{c_E} = x + \frac{e' v^2}{c_E}[\epsilon(2\sigma - \epsilon) - \sigma^2], \tag{9}$$

where the feasibility condition of debt is given by:

$$u'_E = \frac{\pi'^2}{2c_E} - x + d(1-r) \geq \bar{u}. \tag{10}$$

Proof: Using the break-even condition of the venture capitalist, we obtain $e' = \frac{x-d}{s'_E \pi'}$. Thus, the utility of the entrepreneur can be written as $u'_E = s'_E(1 - \frac{x-d}{s'_E \pi'})\pi' - \frac{1}{2}c_E {s'_E}^2$. First order condition yields the optimal effort the entrepreneur will provide, in this case: ${s'}^*_E = \pi'/c_E$. Substituting this effort back in the break-even condition of the venture capitalist, and recognizing that $\pi' = \pi - \epsilon v$ yields the relationship between the magnitude of shock and the debt in Eq. (9). Substituting the optimal effort in the utility of the entrepreneur provides the feasibility condition where the IR constraint is not violated in Eq. (10).

Since $\pi' < \pi$, compared to Eq. 6, the first term $\frac{\pi'^2}{2c_E}$ has a lower value. Thus, due to shock ϵ, there is a reduction in the utility of the entrepreneur from the first term $\frac{\pi'^2}{2c_E}$. However, the utility of the entrepreneur now includes a term $d(1-r)$, which can be viewed as compensation by the venture capitalist to ensure the IR constraint

[39] Since $\sigma - \epsilon > 0$.

of the entrepreneur is met.

Given that equity financing is more prevalent in venture capital and debt financing is forced upon the parties due to the entrepreneur's IR constraint, such rounds should provide just sufficient financing to cover the constraint. If the firm quality subsequently improves, the parties may revert back to all equity financing. This implies that the amount and duration of debt financing rounds should be shorter than an average equity financing round. However, this particular implication is not unique to our framework. Myers (1977) also implies that growth firms use debt financing sparingly.

A.4 Outside Venture Capitalist

Let us now consider a "outside" venture capitalist who neither has a previous equity stake in the firm nor has information about ϵ. This is compared to an "inside" venture capitalist whom we have discussed so far, who has an equity stake and also has private information about the firm. For simplicity, we thus far assumed that the venture capitalist providing the debt breaks even on the debt itself (i.e., $\lambda(1+r) = 1$). For inside investors, this need not be strictly true, even in the presence of perfect competition between capital providers. Indeed, an inside investor has to break even on the total financing provided, which is, expected return on debt and equity (Eq. 8).

For an outside investor who simply provides debt to the firm, the break-even condition is $\lambda(1+r) \geq 1$. This condition gives a lower bound on the outside investor's expectation of successful debt repayment $\lambda \geq 1/(1+r)$ and provides both time series and cross-sectional implications. Cross-sectionally, it suggests that firms that can obtain outside financing in expectation have a higher λ. If the ability to pay back debt, λ, and ability to succeed, σ, are positively correlated, then an implication in time-series is that given a shock ϵ, the value of a firm that is able to borrow from outside investors falls less. Let ρ represent the fall in valuation of the firm.

Proposition A.4 *Given the same exogenous shock, type G firms that can obtain funding from outside venture capitalists have a lower fall in valuation compared to type B firms that cannot, i.e., $\rho_G < \rho_B$.*

Proof: We know change in value of a firm is given by $\rho = 1 - (s'_E\pi')/(s_E\pi)$. Substituting the optimal values of effort by the entrepreneur in the two cases, $s^*_E = \pi/c_E$ and $s'^*_E = \pi'/c_E$, we obtain $\rho = 1 - \pi'^2/\pi^2$. Using identity $\pi = \sigma v$ and $\pi = \sigma' v$ and

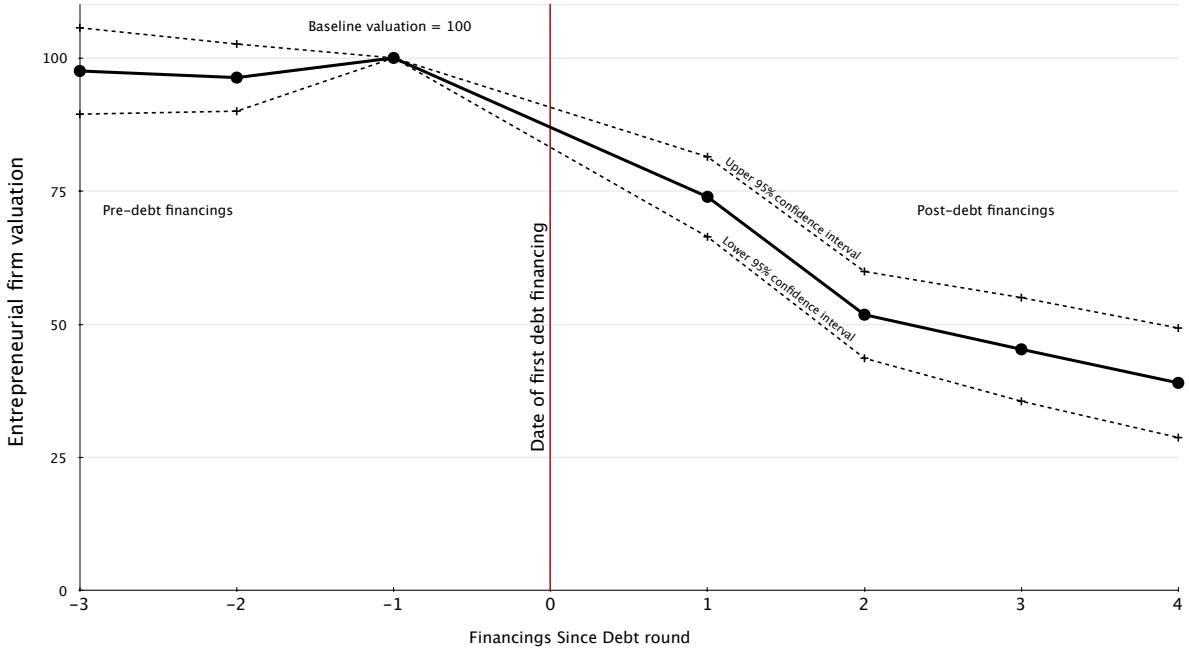
$\sigma' = \sigma - \epsilon$, we obtain $\rho = 1 - (\frac{\sigma-\epsilon}{\sigma})^2$. Since $\sigma_G > \sigma_B$, it follows that $\rho_G < \rho_B$ for the same exogenous shock ϵ.

In summary, the fact that the new venture capitalists have no equity stake in the firm means the quality of the firm must be good enough to provide a non-negative return on debt for the new investors. This choice conveys that even though the firm needed debt, it could obtain it from outside investors. This is a less negative signal about firm quality compared to debt financing by inside investors. Simply put, venture capitalists with existing equity stakes might lend even if the expected return on debt is negative as long as the loss is recouped by a return on their equity stake.

The testable implications can be found in Section 2.

B Figures and Tables

Figure 1: Estimated Change in Valuation Around Debt Financing

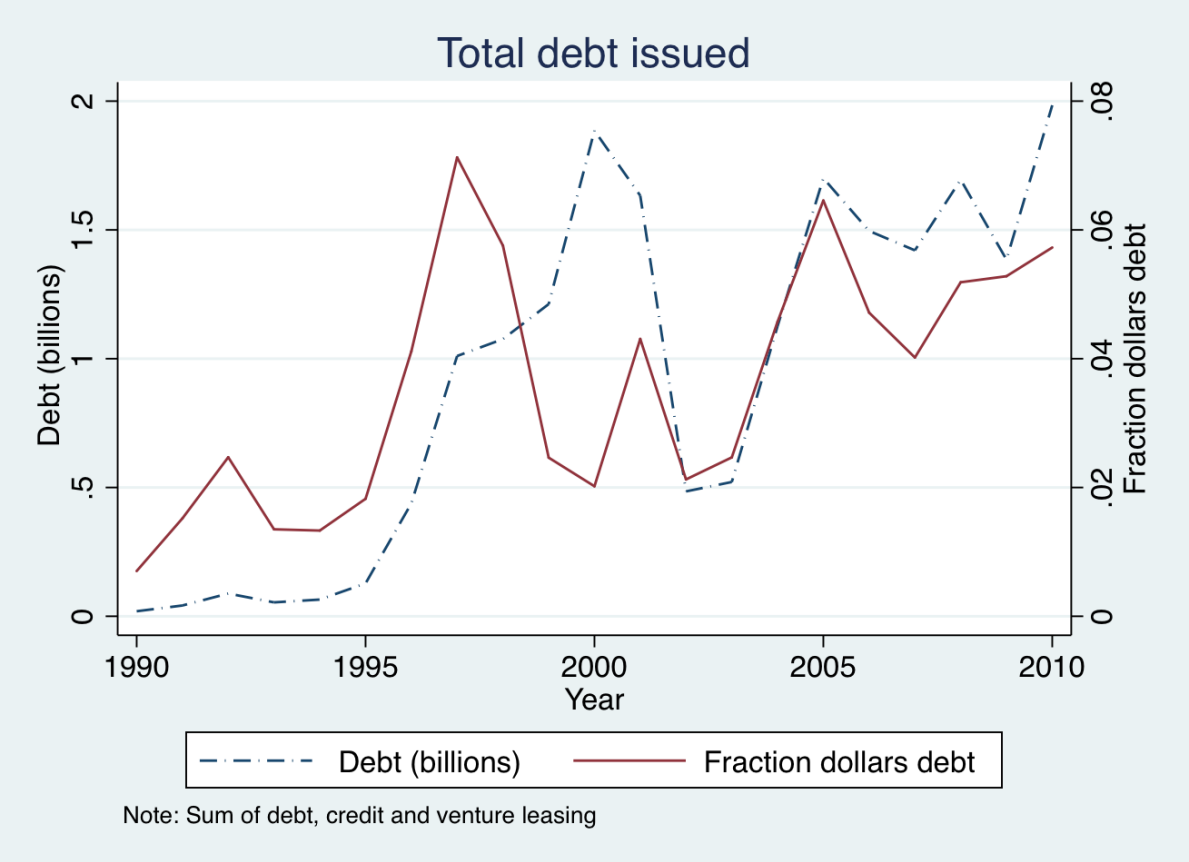


The above figure shows the implied valuation changes based on the coefficients $\hat{\beta}_{1k}$ from the following fixed effects regression:

$$\log(V_{it}) = \beta_0 + \sum_{k=-3, k\neq -1}^{4} \beta_{1k}\text{Financings Since Debt}_{ik} + \beta_2 X_{it} + \alpha_i + \gamma_t + \nu_{it},$$

where the dependent variable is the log pre-money value from financing t and α_i is the entrepreneurial firm's fixed effect. The variable "Financings since debt" characterizes a dummy variable equal to 1 for each financing before and after debt. Hence, a firm with 4 financings before and after their first debt event will have 7 (1 excluded) exclusive dummy variables. The figure presents the estimated series of β_{it} for $t \in [-3, 4]$ where the excluded category is the $t = -1$, or equity financing immediately prior to the first debt financing. A negative estimate suggests growth is slower than the average growth in log value for all financings prior to the debt event. The sample includes 1836 firms that raised debt and had at least one post-debt equity financing (excludes defaults). Regression includes year fixed effects, industry fixed effects and time-varying controls for firm age, total capital raised, round number, and return on the Wilshire index over the previous year.

Figure 2: Relation between Debt Volume and Debt as a Fraction of Overall Capital Invested

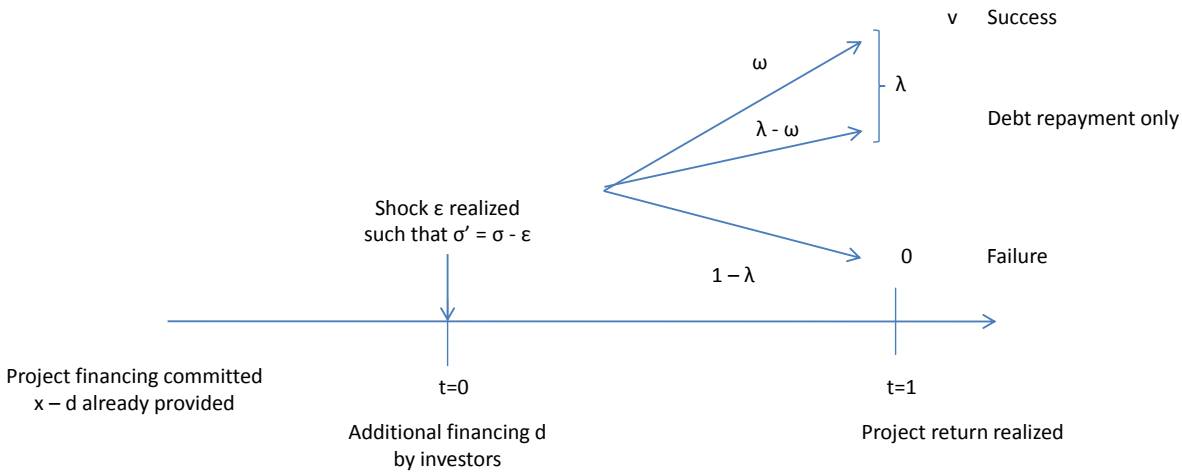


Billions of dollars raised in various debt instruments by venture capital-backed entrepreneurial firms. "Fraction debt" is the total debt raised in a given year divided by the total amount of capital raised in non-exit (e.g. non-IPO) equity investments. Source: VentureSource 1990–2010.

Figure 3: Venture Equity and Debt in Crises

"Log $ raised" is the log of the total dollars invested in equity events for venture capital-backed entrepreneurial firms (by quarter). "Fraction debt" is the fraction debt in all non-exit financings closed in a quarter. The first vertical line is the peak of the Nasdaq Index in 1999 and the second shows the quarter of the Lehman Brothers bankruptcy. Source: VentureSource 1990–2010.

Figure 4: Model Timeline



This figure details the financing process and possible outcomes for a firm. The entrepreneur has commitment of x for a project. With probability ω the firm is successful and is valued at v. With probability $\lambda - \omega$, the firm pays back debt but equity holders receive 0 return. With probability $1 - \lambda$, the firm fails completely and all stake holders receive 0 return. For the parameter $\omega = \sigma s_E$, σ is exogenous and s_E represents effort by the entrepreneur. The contract can be reassessed at time 0 in presence of the shock ϵ, such that the $\sigma' = \sigma - \epsilon$. The shock ϵ has an expectation of 0, and has bounded support. Payoff occurs at time 1.

Table 1: Debt Rounds Over Time

Notes: Count of venture capital debt financings since 1997 broken down by type, as defined by the data provider VentureSource. "Credit" applies to all credit lines, credit facilities, and bank loans that the company receives. Each of these transactions involve no exchange of equity. "Loan" is a loan offered to the company, usually by management or one of its investors. "Debt" is a loan offered to the company from a venture bank or others not currently linked to the firm. "Venture leasing" or venture leasing includes investments in companies that have received at least one round of professional venture capital by corporate leasing agents who take payment in equity as well as debt. This is usually a debt round that includes a traditional debt structure and may include an equity component in the form of warrant coverage. Source: VentureSource 1990–2010.

Debt type	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Credit	0	0	0	3	2	1	23	30	25	17	15	14	21	151
Debt	109	127	144	153	136	132	142	181	187	200	149	348	471	2479
Loan	0	0	0	1	1	0	11	20	11	24	27	15	22	132
Venture leasing	10	61	54	49	23	7	16	17	16	10	10	6	3	282
Total	119	188	198	206	162	140	192	248	239	251	201	383	517	3044
N	3044													

Table 2: Financing Type After Debt

Notes: Tabulation of the types of financings that follow debt financings. "Type" classifies financings as equity, debt or exit (i.e. liquidation). "1st", "2nd", etc. are standard equity financings. "IPO" is initial public offering. "Shutdown" is the firm lacking financing after debt and shutting down. "Other" includes a host of equity rounds and other non-standard exit events.

Round after debt	Type	Count	Freq.	Cum.%
1st	Equity	141	5.13	5.13
2nd	Equity	431	15.68	20.81
3rd	Equity	335	12.19	33.00
4th	Equity	228	8.30	41.30
5th	Equity	111	4.04	45.34
6th	Equity	35	1.27	46.61
Later stage	Equity	81	2.95	49.56
Corp. sponsored	Equity	49	1.78	51.34
Recapitalization	Equity	39	1.42	52.76
Debt	Debt	346	12.59	65.35
Acquisition	Exit	368	13.39	78.74
IPO	Exit	102	3.71	82.45
Asset acquisition	Exit	35	1.27	83.72
Shutdown	Exit	158	5.75	89.47
Other		289	10.52	100
Total	2,748	100.00		

Table 3: Equity vs. debt financings

Notes: Comparison of debt and equity financings for all non-exit financing events post-1992. The sample is restricted to all financings where we can observe the previous equity valuation and thus excludes first financings. Column (4) shows the difference and significance, with the t-statistics in parentheses. "Round #" is the financing sequence number, "Dollars invested (m)" is the total dollars (millions) invested in the financing round. "Log pre-money $t-1$ " is the log pre-money valuation of the previous financing round (if known or imputed). "Firm age (yrs.)" is the age of the firm at the time of the financing. "Profitable" is a dummy equal to one if the firm reports it is profitable at the time of the financing. "Has revenues" is a dummy equal to one if the firm reports earning revenues at the time of the financing. "After debt" is a dummy equal to one if the financing occurs after a debt financing. "Financing year" is the year of the financing event. "Years to next financing" is the years to the next financing (only includes financings that have a follow-on investment). "Capital raised t/capital stock" is the ratio of the current financing amount to total past capital raised (for debt, this mimics D/E). "Capital raised $t+1$/capital raised t" is the ratio of the next capital raised to the current capital raised. t-statistics in parentheses in the "Difference" column with * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

	Equity	Debt	Total	Difference
Round #	3.346	4.181	3.406	-0.835***
	(1.645)	(2.079)	(1.693)	(-21.08)
Dollars invested (m)	10.90	7.063	10.62	3.832***
	(16.25)	(12.38)	(16.03)	(10.15)
Log pre-money $t-1$	2.316	2.890	2.358	-0.574***
	(1.379)	(1.349)	(1.385)	(-17.66)
Firm age (yrs.)	4.536	5.499	4.606	-0.963***
	(3.839)	(4.407)	(3.890)	(-10.51)
Profitable	0.0540	0.104	0.0576	-0.0504***
	(0.226)	(0.306)	(0.233)	(-9.19)
Has revenues	0.637	0.613	0.635	0.0232*
	(0.481)	(0.487)	(0.481)	(2.04)
Financing year	2001.3	2003.7	2001.5	-2.371***
	(4.423)	(4.362)	(4.461)	(-22.74)
Years since last financing	1.287	0.950	1.263	0.337***
	(0.919)	(1.075)	(0.935)	(15.33)
Years to next financing	1.425	1.155	1.406	0.271***
	(1.238)	(1.191)	(1.237)	(9.29)
Capital raised t/capital stock	2.011	0.465	1.889	1.546***
	(3.029)	(1.240)	(2.957)	(22.71)
Capital raised $t+1$/capital raised t	1.986	5.775	2.286	-3.789***
	(15.50)	(33.04)	(17.56)	(-9.29)
Observations	25,029	1,935	26,964	

Table 4: Characteristics of Firms that do and do not Raise Debt

A comparison of entrepreneurial firm characteristics between firms that raise debt and those that do not. See Table 1 for a description of debt events. Negative differences implies firms with debt have a greater mean. "Number financings" is the total financings the firm had before exit or as of the end of the sample. "Information technology" and "Biotech" are firm industry dummy variables. "Publicly-held" is a dummy for whether the entrepreneurial firm had an IPO and "Acquired" is a dummy for whether they were acquired. "Still private" indicates whether the firm was still privately-held as of the end of the sample. "Age at exit or end of sample" is the number of years between the firm's founding and the exit or end of the sample. "Total capital raised" is the sum of all capital raised over the firm's life excluding the exit event (e.g. IPO). Standard errors in parentheses and t statistics in brackets []. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Source: VentureSource 1990–2010.

	No debt	Had debt	Total	Difference test
Year founded	2000.5	2000.8	2000.6	-0.185
	(5.944)	(4.756)	(5.810)	[-1.45]
Founded California	0.395	0.344	0.389	0.0441***
	(0.489)	(0.475)	(0.488)	[4.29]
Founded Massachusetts	0.104	0.111	0.105	-0.00874
	(0.305)	(0.315)	(0.307)	[-1.36]
Founded New York	0.0621	0.0376	0.0591	0.0272***
	(0.241)	(0.190)	(0.236)	[5.40]
Number financings	3.070	4.054	3.193	-1.078***
	(1.699)	(2.019)	(1.772)	[-29.38]
Information technology	0.518	0.457	0.510	0.0581***
	(0.500)	(0.498)	(0.500)	[5.51]
Biotech	0.203	0.291	0.214	-0.0925***
	(0.402)	(0.454)	(0.410)	[-10.81]
Publicly held	0.0977	0.0756	0.0949	0.0158**
	(0.297)	(0.264)	(0.293)	[2.64]
Out of business	0.213	0.127	0.203	0.0779***
	(0.410)	(0.334)	(0.402)	[9.34]
Acquired	0.279	0.252	0.276	0.0391***
	(0.449)	(0.434)	(0.447)	[4.09]
Still private	0.392	0.508	0.406	-0.113***
	(0.488)	(0.500)	(0.491)	[-10.95]
Age at exit or end of sample (yrs.)	3.313	5.207	3.550	-1.988***
	(3.065)	(3.448)	(3.178)	[-29.55]
Total capital raised (log $)	2.286	3.069	2.384	-0.783***
	(1.561)	(1.453)	(1.569)	[-23.54]
Observations	19,577	2,602	22,179	

Table 5: Inside vs. Outside Debt Financings

Notes: Comparison of debt financings provided by existing shareholders (i.e. "insiders") and non-shareholders (i.e. "outsiders") for all non-exit financing events post-1992. The sample is restricted to all financings where we can observe the previous equity valuation and thus excludes first financings. Column (4) shows the difference and significance, with the standard errors in parentheses. A positive value implies the inside debt financing has a larger value of the variable. Variables are as defined in Table 3 t-statistics in brackets for "Difference" column with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Inside debt	Outside debt	Total	Difference
Round #	4.413	4.113	4.249	0.300**
	(2.212)	(1.995)	(2.101)	[3.19]
Dollars invested (m)	5.797	7.993	6.999	-2.196***
	(11.80)	(12.57)	(12.27)	[-4.01]
Log pre-money t-1	2.678	3.070	2.893	-0.393***
	(1.411)	(1.251)	(1.339)	[-6.61]
Firm age (yrs.)	6.027	5.195	5.572	0.832***
	(4.362)	(4.423)	(4.414)	[4.22]
Profitable	0.107	0.103	0.105	0.00389
	(0.309)	(0.304)	(0.306)	[0.28]
Has revenues	0.636	0.588	0.610	0.0481*
	(0.481)	(0.492)	(0.488)	[2.20]
Financing year	2004.1	2003.5	2003.8	0.617**
	(4.898)	(3.796)	(4.339)	[3.18]
Years since last financing	1.101	0.958	1.023	0.143**
	(1.144)	(1.148)	(1.148)	[2.78]
Years to next financing	1.179	1.268	1.228	-0.0897
	(1.260)	(1.279)	(1.271)	[-1.57]
Capital raised $t+1$/capital raised t	5.316	6.155	5.775	-0.838
	(20.49)	(40.59)	(33.04)	[-0.57]
Observations	1,099	9,09	2,008	

Table 6: Debt and Within-firm Valuation

Notes: Fixed effects regressions of entrepreneurial firm post-money valuation on a series of controls. The sample includes all equity financings for venture capital-backed firms founded after 1990 that had at least one debt financing in their history and at least an equity event pre- and post-debt event. We exclude firms that never raised debt as the variable of interest cannot be identified otherwise. The first three columns use the simple log level of pre-money (i.e. pre-financing) valuation. The last three columns have round to round valuation growth – Pre$\$_t$/Post$\$_{t-1}$ – as the dependent variable. "No defaults" excludes firms that shut down after the debt event before another financing. "No exits" excludes firms whose debt event was immediately followed by any type of exit. A debt event includes loans, lines of credit and venture leasing, but does not include bridge loans due to inconsistencies in the VentureSource data. If the dependent variable is unavailable, the valuation is imputed using the model of Hall and Woodward (2010) (See Section 2.1). "n financings prior (after) debt" is a dummy variable for each financing around the first debt event ($n \in [-3, 4]$) with the excluded financing immediately prior to the debt round. Standard errors in parentheses, clustered at the firm level to address serial correlation in the error term. * , **, *** represent significance at the 10%, 5% and 1% level respectively.

	log(Pre$)			Pre$\$_t$/Post$\$_{t-1}$		
Financing rounds since debt	All firms	No defaults	No exits	All firms	No defaults	No exits
	(1)	(2)	(3)	(4)	(5)	(6)
-3	0.00121	-0.0239	-0.0260	0.279	0.286	0.344
	(0.0436)	(0.0424)	(0.0546)	(0.253)	(0.262)	(0.337)
-2	-0.0129	-0.0371	-0.0399	0.106	0.0944	0.150
	(0.0334)	(0.0334)	(0.0405)	(0.183)	(0.193)	(0.232)
1	-0.469***	-0.301***	-0.458***	-0.423*	-0.318	-0.576**
	(0.0532)	(0.0518)	(0.0586)	(0.242)	(0.255)	(0.269)
2	-0.770***	-0.655***	-0.745***	-0.998***	-0.925***	-1.204***
	(0.0800)	(0.0803)	(0.0855)	(0.334)	(0.341)	(0.353)
3	-0.908***	-0.786***	-0.875***	-0.714**	-0.627*	-0.877**
	(0.109)	(0.110)	(0.115)	(0.336)	(0.342)	(0.358)
4	-1.103***	-0.933***	-1.070***	-0.719*	-0.621	-0.878**
	(0.134)	(0.135)	(0.140)	(0.380)	(0.383)	(0.395)
Observations	7597	7138	6040	5436	5111	4426
R^2	0.321	0.343	0.305	0.056	0.054	0.061
Firms	1984	1836	1505	1790	1656	1399
Firm FE?	Y	Y	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y	Y	Y

Table 7: Valuation Before and After Debt

Notes: Fixed effect regressions of entrepreneurial firm pre-money valuation on a series of controls. The sample includes all equity financings for venture capital-backed firms founded after 1990 that had at least one debt financing in their history and at least an equity event pre- and post-debt event. Column (2), "No defaults", excludes firms that shut down after the debt event before another financing. Column (3), "No exits", excludes firms whose debt event was immediately followed by any type of exit. A debt event includes loans, lines of credit, and venture leasing, but does not include bridge loans due to inconsistencies in the VentureSource data. If the dependent variable is unavailable, the valuation is imputed using the model of Hall and Woodward (2010) (See Section 2.1). "After debt" is equal to one for all equity financings or exit events that occur after a debt financing. "Debt / Last equity" is the debt amount over the previous equity capital raised interacted with the "After debt" variable (after winsorizing the ratio). "Firm age" is the age in years of the entrepreneurial firm at a financing event. "Profitable" is equal to one if the firm reported profits and "Positive revenue" is equal to one if the firm reported revenues. The variable "1 year Wilshire return" is the return on the Wilshire 5000 from one year prior to the financing. "Total capital raised (m)" is the sum of total equity capital raised (zero if first financing) prior to the current financing. Standard errors in parentheses, clustered at the firm level to address serial correlation in the error term. * , **, *** represent significance at the 10%, 5% and 1% level respectively.

	All firms	No defaults	No exits	All firms
	(1)	(2)	(3)	(4)
After debt	-0.521***	-0.354***	-0.540***	
	(0.0544)	(0.0523)	(0.0600)	
Debt/Last Equity				-0.0973**
				(0.0381)
Profitable	0.516***	0.370***	0.474***	0.464***
	(0.119)	(0.117)	(0.136)	(0.129)
Positive revenue	0.373***	0.255***	0.412***	0.386***
	(0.0567)	(0.0578)	(0.0619)	(0.0600)
Log firm age (yrs.)	0.0526	0.0598*	0.0496	0.0780**
	(0.0358)	(0.0363)	(0.0423)	(0.0370)
Log round no.	0.864***	1.027***	0.782***	0.608***
	(0.0622)	(0.0620)	(0.0700)	(0.0659)
Total capital raised (m)	-0.00463***	-0.00359***	-0.00484***	-0.00451***
	(0.00141)	(0.00134)	(0.00171)	(0.00159)
1 year Wilshire return	0.577***	0.561***	0.536***	0.618***
	(0.127)	(0.125)	(0.139)	(0.136)
Observations	7837	7372	6200	6860
R^2	0.330	0.350	0.309	0.312
Firms	1987	1838	1508	1847
Firm FE?	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y

Table 8: Comparing Firms With and Without Debt

Notes: This table shows the OLS estimates of the θ_k^0 from Eq. (3) where the dependent variable is the log pre-money valuation of the firm. An observation is an entrepreneurial firm equity or exit financing event for 1995–2010. Each k represents a financing event around a firm's first debt financing. The sample includes both firms that raise debt and those that do not. The "Diff-in-diff" row shows the implied differences in valuation between the valuation immediately prior to the debt round and k financings after (each relative to the baseline controls in the same year and industry). A negative value for this difference implies a fall in valuation relative to the baseline after the debt financing. "Controls" include the log of total capital raised, the financing sequence number, age of the firm, years since previous financing, and dummies for whether the firm had revenues or was profitable at the time of financing. "Year FE" are dummies for the financing year and "Industry FE" are dummies for the firm's industry. Panel B shows all firms, but excludes exits rounds of IPOs, acquisitions and failures. Panel C shows all financings of firms that failed by the end of the sample. Standard errors clustered at the entrepreneurial firm where * , **, *** represent significance at the 10%, 5% and 1% level respectively.

All firms

48,471 observations, 18,412 firms, dependent variable log pre-money valuation

	Financings Since Debt Round							
Panel A	-4	-3	-2	-1	1	2	3	4
θ_k	-0.077	0.08**	0.172***	0.297***	-0.089***	-0.290***	-0.494***	-0.724***
s.e.	(0.061)	(0.039)	(0.033)	(0.029)	(0.043)	(0.061)	(0.086)	(0.128)
					$\hat{\theta}_k$ - $\hat{\theta}_{-1}$			
Diff-in-diff					-0.386***	-0.587***	-0.791***	-1.021***
t-stat					81.33	83.64	77.65	60.73
R^2	0.27	Controls?	Y	Industry FE?	Y	Year FE?	Y	N 48,471

All firms, no exit rounds

43,790 observations, 17,689 firms, dependent variable log pre-money valuation

	Financings Since Debt Round							
Panel B	-4	-3	-2	-1	1	2	3	4
θ_k	-0.001	0.147***	0.244***	0.370***	-0.046	-0.283***	-0.539***	-0.749***
s.e.	(0.061)	(0.039)	(0.032)	(0.029)	(0.044)	(0.059)	(0.082)	(0.124)
					$\hat{\theta}_k$ - $\hat{\theta}_{t-1}$			
Diff-in-diff					-0.416***	-0.652***	-0.908***	-1.119***
t-stat					87.45	111.24	113.17	77.61
R^2	0.25	Controls?	Y	Industry FE?	Y	Year FE?	Y	N 43,790

No failure and no exit rounds

34,940 observations, 14,132 firms, dependent variable log pre-money valuation

	Financings Since Debt Round							
Panel C	-4	-3	-2	-1	1	2	3	4
θ_k	-0.192***	0.003	0.090***	0.218***	-0.036	-0.185***	-0.457***	-0.744***
s.e.	(0.062)	(0.040)	(0.034)	(0.031)	(0.038)	(0.053)	(0.073)	(0.115)
					$\hat{\theta}_k$ - $\hat{\theta}_{-1}$			
Diff-in-diff					-0.254***	-0.403***	-0.675***	-0.962***
t-stat					40.15	51.42	75.86	66.31
R^2	0.35	Controls?	Y	Industry FE?	Y	Year FE?	Y	N 34,940

Table 9: Debt in the Cross-Section

Notes: Cross-sectional regressions using the sample of entrepreneurial firms founded prior to 2003. The "IPO/Acq." probit regressions has a dependent variable is equal to one if the entrepreneurial firm exited via IPO or acquisition as of the end of the first quarter of 2011. log(Exit value) is the log of the final sale price of the firm at IPO, acquisition (if reported) or at shutdown (set to 20% of total capital raised). "CEO change" is a binary variable equal to one if the firm had multiple CEOs (using a probit regression). "Had debt round" is equal to one if the firm ever issued debt. "Debt / last equity" is the debt raised over the previous equity financing (zero if no debt raised). "Total capital raised" is the sum of all capital raised by the entrepreneurial firm. "Age at exit or end of sample" assumes the first observed investment is the founding date of the entrepreneurial firm and defines age as the number of years to an exit or end of the sample (3/31/2011). "Number financings" is the log total number of financings. All regressions include controls for region and industry. "Region FE" is a dummy for firms founded in California, Massachusetts and New York. Standard errors in parentheses. * , **, *** represent significance at the 10%, 5% and 1% level respectively.

	IPO/Acq. (1)	log(Exit value) (2)	CEO change (3)	IPO/Acq. (4)	log(Exit value) (5)	CEO change (6)
Had debt round	-0.210***	-0.201**	0.0846**	-0.331***	-0.514***	0.154***
	(0.0374)	(0.0823)	(0.0427)	(0.0513)	(0.123)	(0.0583)
Debt / last equity				0.158***	0.276***	-0.144***
				(0.0432)	(0.0962)	(0.0533)
Total capital raised (log $)	0.409***	1.139***	0.0497***	0.409***	1.147***	0.0542***
	(0.0127)	(0.0195)	(0.0118)	(0.0128)	(0.0186)	(0.0125)
Age at exit or end of sample (yrs)	-0.0177***	-0.00458	0.0308***	-0.0174***	-0.00455	0.0289***
	(0.00299)	(0.00396)	(0.00286)	(0.00298)	(0.00396)	(0.00296)
log number financings	-0.362***	-0.846***	0.490***	-0.364***	-0.846***	0.479***
	(0.0310)	(0.0587)	(0.0429)	(0.0314)	(0.0584)	(0.0455)
Observations	15003	7871	10204	14738	7790	9048
R^2		0.452			0.456	
Pseudo R^2	0.220		0.082	0.220		0.065
Year founded FE?	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y

Table 10: Valuation Over Time: Outside Debt

Notes: Fixed effects regressions of entrepreneurial firm valuation on a series of controls. The sample includes all equity financings for venture capital-backed firms founded after 1990 that had at least one debt financing in their history and at least an equity event pre- and post-debt event. A debt event includes loans, lines of credit and venture leasing, but does not include bridge loans due to inconsistencies in the VentureSource data. The dependent variable is the post-money valuation. If unavailable, the valuation is imputed using the model of Hall and Woodward (2010). "No default" excludes all the financings of firms that failed after a debt round and "No exits" excludes the financings of firms that borrowed immediately prior to an IPO or acquisition. Columns labeled "Inside" are those debt rounds financed completely by inside investors, while "Outside" columns have debt lent by at least one investor not an existing equity holder. All other variables as defined in Table 7. Standard errors in parentheses, clustered at the firm level to address serial correlation in the error term. * , **, *** represent significance at the 10%, 5% and 1% level respectively.

	All firms Inside	All firms Outside	No default Inside	No default Outside	No exits Inside	No exits Outside
	(1)	(2)	(3)	(4)	(5)	(6)
After debt	-0.836***	-0.436***	-0.571***	-0.311***	-0.724***	-0.489***
	(0.102)	(0.0628)	(0.100)	(0.0596)	(0.118)	(0.0672)
Profitable	0.473**	0.464***	0.303	0.349**	0.614**	0.379**
	(0.199)	(0.139)	(0.193)	(0.138)	(0.243)	(0.157)
Positive revenue	0.436***	0.297***	0.266***	0.221***	0.613***	0.296***
	(0.0922)	(0.0659)	(0.0967)	(0.0659)	(0.106)	(0.0692)
Log firm age (yrs.)	0.0377	0.0244	0.0603	0.0264	0.0386	-0.0169
	(0.0580)	(0.0423)	(0.0604)	(0.0423)	(0.0716)	(0.0481)
Log round no.	0.587***	0.793***	0.772***	0.927***	0.425***	0.783***
	(0.0936)	(0.0763)	(0.0931)	(0.0769)	(0.110)	(0.0866)
1 year Wilshire return	0.253	0.495***	0.183	0.500***	0.180	0.437**
	(0.205)	(0.161)	(0.198)	(0.159)	(0.222)	(0.176)
Observations	2802	5049	2561	4825	2105	4105
R^2	0.276	0.303	0.265	0.319	0.270	0.288
Firms	746	1238	673	1163	535	970
Firm FE?	Y	Y	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y	Y	Y

Table 11: Comparing Inside and Outside Debt over Time

Notes: This table shows the OLS estimates of the θ_k^I and θ_k^O from the following specification:

$$V_{it} = \beta_0 + \sum_{k=-4}^{4} \theta_k^I \text{In}_{t+k} + \sum_{k=-4}^{4} \theta_k^O \text{Out}_{t+k} + \beta_1 Z_{it} + \gamma_t + I_i + \nu_{it},$$

where the dependent variable is the log pre-money valuation of the firm. An observation is an entrepreneurial firm equity or exit financing event for 1995–2010. Each k represents a financing event around a firm's first debt financing. Sample includes both firms that raise debt and those that do not. "Inside debt" reports the coefficient θ_k^I and "Outside debt" reports the coefficients θ_k^O. The "Diff-in-diff" row shows the implied differences in valuation between the valuation immediately prior to the debt round and k financings after (each relative to the baseline controls in the same year and industry). A negative value for this difference implies a fall in valuation relative to the baseline after the debt financing. "(Inside debt - Outside debt)" shows the difference in valuation for k periods since debt for inside and outside debt financings. A negative value of this difference implies inside rounds have a smaller (or more negative) predicted fall in valuation. See Table 8 for definitions of controls and FE. Standard errors clustered at the entrepreneurial firm where * , **, *** represent significance at the 10%, 5% and 1% level respectively.

All firms

48,471 obs, 18,412 firms, dependent variable log pre-money valuation

		Financings Since Debt Round							
		-4	-3	-2	-1	1	2	3	4
Inside debt	θ_k^I	-0.258**	0.075	0.044	0.013	-0.427***	-0.578***	-0.819***	-0.609*
	s.e.	(0.108)	(0.062)	(0.052)	(0.046)	(0.079)	(0.128)	(0.227)	(0.335)
		$\hat{\theta}_k^I - \hat{\theta}_{-1}^I$							
	Diff-in-diff					-0.439***	-0.591***	-0.831***	-0.622*
	t-stat					31.35	20.47	12.82	3.42
		-4	-3	-2	-1	1	2	3	4
Outside debt	θ_k^O	0.021	0.088*	0.256***	0.479***	0.090*	-0.201***	-0.412***	-0.752***
	s.e.	(0.072)	(0.050)	(0.041)	(0.035)	(0.047)	(0.068)	(0.090)	(0.137)
		$\hat{\theta}_k^O - \hat{\theta}_{-1}^O$							
	Diff-in-diff					-0.390***	-0.680***	-0.892***	-1.231***
	t-stat					61.19	85.25	85.46	75.16
		$\hat{\theta}_k^I - \hat{\theta}_k^O$							
(Inside debt −	Diff-in-diff	-0.279**	-0.013	-0.212***	-0.467***	-0.517***	-0.378***	-0.406*	0.143
Outside debt)	t-stat	4.66	0.03	10.66	67.36	32.64	6.96	2.78	0.16
R^2	0.27	Controls?	Y	Industry FE?	Y	Year FE?	Y		

Table 12: Debt in the Cross-Section: Outside Investors

Notes: Cross-sectional regressions using the sample of entrepreneurial firms founded prior to 2006. Sample only includes firms that ever raised debt and compares outcomes based on the source of that debt. The "IPO/Acq." column present a probit regression with the dependent variable of 1 if the entrepreneurial firm exited via IPO or acquisition as of the end of the first quarter of 2011. log(Exit value) is the log of the final sale price of the firm at IPO, acquisition (if reported) or at shutdown (set to 20% of total capital raised). "CEO change" is a binary variable equal to one if the firm had multiple CEOs (using a probit regression). "Outside debt" is 1 if the firm raised debt from an investor who did not already own equity in the firm. "% outside investors" is the percentage of investors in the debt financing that did not hold equity stakes before the event. "Total capital raised" is the sum of all capital raised by the entrepreneurial firm. "Age at exit or end of sample" assumes the first observed investment occurred on the founding date of the entrepreneurial firm and define age as the number of years to an exit or end of the sample (3/31/2011). "Number financings" is the log total number of financings. All regressions include controls for region and industry. Standard errors in parentheses. * , **, *** represent significance at the 10%, 5% and 1% level respectively.

	IPO/Acq. (1)	log(Exit value) (2)	CEO change (3)	IPO/Acq. (4)	log(Exit value) (5)	CEO change (6)
Outside debt	0.344***	0.630***	-0.0726	0.371***	0.729**	0.00972
	(0.0756)	(0.224)	(0.0794)	(0.0964)	(0.355)	(0.102)
% outside investors				-0.0468	-0.138	-0.140
				(0.106)	(0.351)	(0.112)
Total capital raised (log $)	0.350***	0.883***	0.0294	0.352***	0.884***	0.0321
	(0.0414)	(0.125)	(0.0351)	(0.0411)	(0.125)	(0.0351)
Age at exit or end of sample (yrs)	0.0189***	0.0510**	0.0187**	0.0188***	0.0506**	0.0183**
	(0.00710)	(0.0243)	(0.00829)	(0.00710)	(0.0241)	(0.00831)
log number financings	0.200**	-0.494	0.221**	0.197**	-0.492	0.209*
	(0.0897)	(0.372)	(0.110)	(0.0903)	(0.372)	(0.111)
Observations	2018	498	1278	2018	498	1278
R^2		0.385			0.385	
Pseudo R^2	0.222		0.062	0.222		0.063
Industry FE?	Y	Y	Y	Y	Y	Y
Year founded FE?	Y	Y	Y	Y	Y	Y

Table 13: Valuation Before and After Debt: No Imputation

Notes: This sample contrasts with those above that use imputed valuations from Hall and Woodward (2010) and excludes all imputed valuations. The specification is a fixed effects regressions of entrepreneurial firm post-money valuation on a series of controls. Sample includes all equity financings for venture capital-backed firms founded after 1990 that had at least one debt financing in their history and at least an equity event pre- and post-debt event. A debt event includes loans, lines of credit, and venture leasing, but does not include bridge loans due to inconsistencies in the VentureSource data. The dependent variable is the entrepreneurial firm's post-money valuation, which is only used if reported in VentureSource. "After debt" is equal to one for all equity financings or exit events that occur after a debt financing. "Debt / Last equity" is the debt amount over the previous equity capital raised interacted with the "After debt" variable (after winsorizing the ratio). Columns are defined as in Table 7. Other control variables mimic those in Table 7 with the inclusion of industry and financing year fixed effects (not reported). Standard errors in parentheses, clustered at the firm level to address serial correlation in the error term. * , **, *** represent significance at the 10%, 5% and 1% level respectively.

	All firms	No defaults	No exits	All firms
	(1)	(2)	(3)	(4)
After debt	-0.735***	-0.693***	-0.758***	
	(0.0821)	(0.0825)	(0.0850)	
Debt/Last Equity				-0.235***
				(0.0589)
Profitable	0.786***	0.710***	0.815***	0.717***
	(0.164)	(0.165)	(0.176)	(0.173)
Positive revenue	0.436***	0.370***	0.420***	0.448***
	(0.0831)	(0.0854)	(0.0842)	(0.0871)
Log firm age (yrs.)	0.0514	0.0590	0.0839	0.106*
	(0.0532)	(0.0529)	(0.0561)	(0.0555)
Log round no.	0.747***	0.868***	0.685***	0.466***
	(0.0961)	(0.0967)	(0.0994)	(0.102)
1 year Wilshire return	0.633***	0.617***	0.521**	0.716***
	(0.224)	(0.228)	(0.239)	(0.238)
Observations	4009	3825	3458	3522
R^2	0.376	0.380	0.379	0.354
Firms	1545	1409	1130	1348
Firm FE?	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y