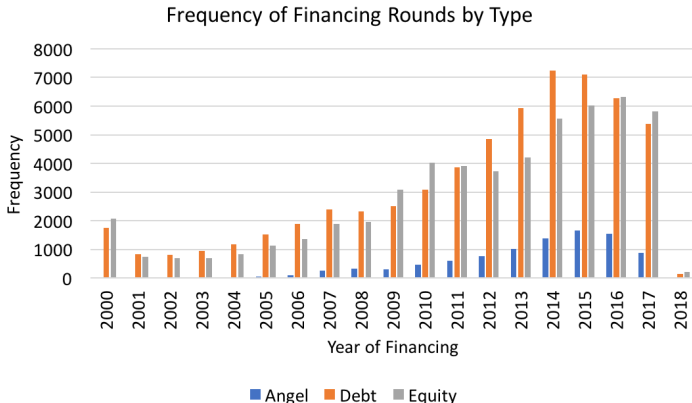# The Leveraging of Silicon Valley:
Venture Debt in the Innovation Economy

Jesse Davis, Adair Morse, Xinxin Wang

July 3, 2018

Motivation

Debt issuance by start-ups has increased exponentially since 2000.

Frequency of Financing Rounds by Type

In particular, **venture debt** is utilized in **28-40% of all financing** rounds.

Venture Debt Characteristics

Venture debt is not mezzanine debt:

- Senior in the priority structure
- Short-term loan (36 months)
- Typical interest rate is prime + 5-10%
- First 6 months, IO. After, monthly payments of P&I
    - Effectively **repaid through future equity issuance** (Hochberg et al. (2018))
    - Some cases, patents serve as collateral (Ibrahim (2010), De Rassenfosse and Fischer (2016), Gonzalez-Uribe and Mann (2017))
- Includes "small" (1-2%) fraction of warrants
- Issued early in firm's life cycle (e.g., after Series A)
- Common role: **extend the "runway"**
    - Firms utilize venture debt to delay raising equity
    - Additional time provides start-ups a chance to reach future milestones

EValve Inc.

- Minimally invasive cardiac valve repair technology startup
- Raised $117 million in debt and equity
- Acquired by Abbott in 2009 for $410 million

Founded   *B*   *Debt*   *C*   *Debt*   *Acquired*

$12*M* $4*M* $20*M* $10*M* $410*M*

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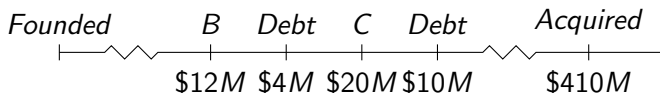
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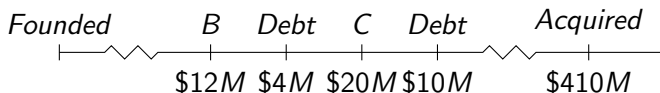
"by allowing us to **hit a critical milestone** *with that extra run time, even though drawing down the debt costs warrants and interest, our experience was that it paid for itself by* **increasing valuation and avoiding dilution**" *- Ferolyn Powell, CEO*

Why Venture Debt?

Industry insiders claim that venture debt is used to minimize dilution:

- True ... but *only if firm actually hits milestones!*

- Absent other frictions, no effect on ex-ante equity value.

Motivation

This paper: theoretical foundation and empirical support for the use and implications of venture debt.

1. Establish conditions under which venture debt is optimal
   - Venture debt preserves entrepreneurial incentives
     - Traditional role of debt and risking up
     - Novel channel: Raising equity cheaply preserves "skin-in-the-game"
2. Consider implications of debt on firm outcomes
   - Runway, Ability to raise capital
   - Closure, Acquisitions, IPO

Outline

Model Setup: Asset

- There are three dates, $t \in \{0, 1, 2\}$.
- Firm owns a risky asset which pays $\gamma \mathbf{Y}$ at $t = 2$.
- Must invest X_0, X_1, X_2 for asset to have value $(Y > 0)$.
  - Required capital raised from competitive, outside investors.

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$\mathbf{t = 2}$: γ (e.g., a pricing multiple) is realized.

$$\gamma = \begin{cases} \tilde{\gamma} + \delta & \text{w/ prob. } \tau \\ \tilde{\gamma} & \text{w/ prob. } p_1 - 2\tau \\ \tilde{\gamma} - \delta & \text{w/ prob. } 1 - p_1 + \tau \end{cases}$$

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- Choice of $\tau \in [0, \tau_h]$ **controls firm-level risk**

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$\mathbf{t = 0}$: $p_1 \in \{p_h, p_l\}$, unconditional firm quality, $p_0 \equiv \mathbb{E}_0[p_1]$

An initial VC (owns θ) and entrepreneur (owns $1 - \theta$) run the firm.

Model Setup: Agents

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At t=0, the VC chooses how/when to raise capital:

- Raise $X_0 + X_1$ via equity ("upfront" financing)
- Raise X_0 via equity ("staged" financing)
  - At $t = 1, 2$ X_1, X_2 raised via equity if feasible.
- **Raise $X_0 - \mathbb{E}[D]$ via equity ($D \equiv$ venture debt)**
  - At $t = 1, 2$ **$X_1 + D, X_2$** raised via equity if feasible

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At t=1, the entrepreneur chooses firm strategy (τ) to maximize

$$\underbrace{A_1 \mathbb{E}[(1 - \alpha_2)\gamma Y | p_1, \tau]}_{\text{Diluted Payoff}} + \underbrace{b\mathbb{P}[Y > 0 | p_1, \tau]}_{\text{Continuation Utility}},$$

- An increase in risk ($\uparrow \tau$) $\implies$ an increase in the entrepreneur's payoff but a decrease in the private benefit.

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- An increase in risk ($\uparrow \tau$) $\implies$ an increase in the entrepreneur's payoff but a decrease in the private benefit.
- **VC utilizes capital structure to incent risk-taking.**

Optimal Strategy

Entrepreneur chooses high-risk/high-value ($\tau = \tau_h$) $\iff$

$$\underbrace{A_1}_{\text{Entrepreneur's Stake}} \geq \frac{b}{\delta Y - (\tilde{\gamma} Y - X_2)} \qquad (1)$$

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Suppose the VC raises all funds ($X_0 + X_1$) via equity at $t = 0$.

- **No capital raised at $t = 1$ $\implies$ same risk-taking for p_l, p_h**
  - Entrepreneur stake (A_1^0) independent of realized milestone.

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Suppose the VC delays and raises some capital at $t = 1$.

- Entrepeneur dilution minimized if $p_1 = p_h$ (reach milestone).
  - Moreover, $A_1(p_h) > A_1^0 > A_1(p_l)$.
- **Firm strategy/value depend upon information revealed**

Why Issue Venture Debt?

If ex-ante prospects are good, firm raises $X_0 + X_1$ at $t = 0$.

- Firm can raise equity "cheaply" and always takes risk.

Otherwise, the firm delays, and takes risk when $p_1 = p_h$.

- If milestone hit, can raise equity cheaply, $\downarrow$ dilution
  - **Issuing venture debt amplifies this benefit.**
- Valuable even if firm fails when milestone missed ($p_1 = p_l$).
  - Debt increases the required threshold for financing at $t = 1$.

Result 1: The firm is more likely to issue venture debt if

1. $\downarrow$ required capital until milestone (X_0)
2. $\uparrow$ entrepreneur's initial dilution
3. $\downarrow$ unconditional value of the firm (p_0)

Impact of Venture Debt

Result 2: The optimal use of venture debt $\uparrow$ firm value,

1. $\uparrow$ probability of short-term failure
2. $\uparrow$ firm's expected value, conditional on survival
3. $\downarrow$ firm's expected dilution

Impact of Venture Debt

Result 2: The optimal use of venture debt ↑ firm value,

1. ↑ probability of short-term failure
2. ↑ firm's expected value, conditional on survival
3. ↓ firm's expected dilution

Note: similar predictions arise if short-term debt issued at $t = 1$.

- If the required milestone at t=2 is unchanged, debt
  - increases equity sensitivity (standard channel)
  - increases upside benefit from risk-taking (convexity)
- Otherwise, debt can **force "risking up"** by entrepreneur.
  - In order to repay debt, risky strategy must be chosen.
  - ↑ firm value if enough risk can be taken, $\tau_h > \underline{\tau}$

Data

- Crunchbase - a crowdsourced database that tracks startups
  - 62,403 firms and 135,069 financing rounds between 2000-2017
- Firm level characteristics
  - Founding team, founding date, current status (ongoing, inactive), exit status (IPO, acquired), employee count, industry
  - News and dates
    - Allows us to correctly account for closures
- Round level characteristics
  - Date, investors, syndication, type of financing, investment amount, stage of financing (series A,B,C), premoney valuation

Summary Statistics

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

Choice of Debt vs. Equity

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

Choice of Debt vs. Equity

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

Duration

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

Survival

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

Survival

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

Cox Proportional Hazard Analysis of Exit Risk

Sample: Funding Round Agings

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

Conclusion

- Dilution is an important determinant of the use of venture debt (7% in Seed and Series A rounds, 2% in Series B rounds)
  - Novel theoretical channel that is aligned with what practitioners believe
  - "Skin-in-the-game" incents entrepreneurs to choose high-risk, high-value strategies
- Venture debt serves as a runway extension for firms that did not reach their milestones
  - Low valuation increases lead to an increase likelihood of raising debt over equity
- Consistent with the theoretical predictions of the implications of venture debt on firm outcomes
  - Startups are more likely to fail
  - But are also more likely to be acquired