

Economics of New Ventures and Innovation

Venture Capital

Joacim Tåg

Fall 2023

Venture capital

The growth and impact of the venture capital industry

How do venture capitalists make decisions?

Venture capital and experimentation

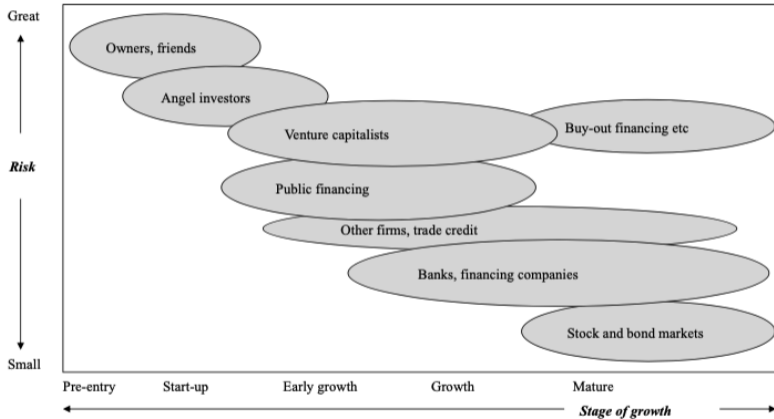
Limitations of venture capital

Venture capital

Venture capital

The growth and impact of the venture capital industry

Introduction



Venture capital

- Venture capital emerged in 1946 with the American Research and Development Corporation in Boston formed to invest in ventures formed during WW2 (took of with ERISA in 1979)
 - Intense screening of business plans
 - Provision of monitoring
 - Provision of capital
 - Staged financing
 - Return of capital and profits to outside investors
- Venture capital as an institution evolved to counter problems that arise because of **moral hazard and asymmetric information**

The structure of venture capital (Da Rin, Hellmann and Puri 2013)

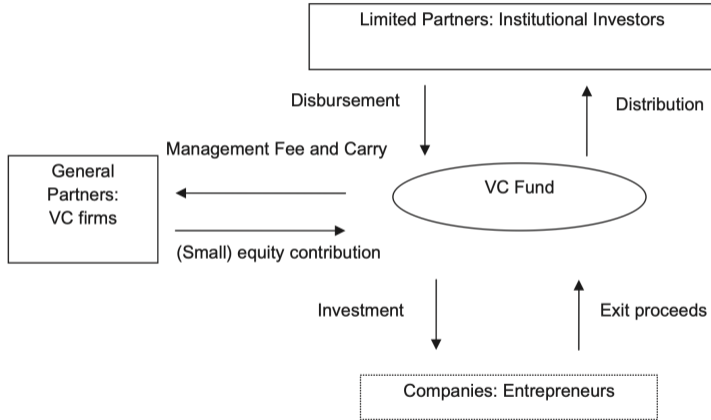
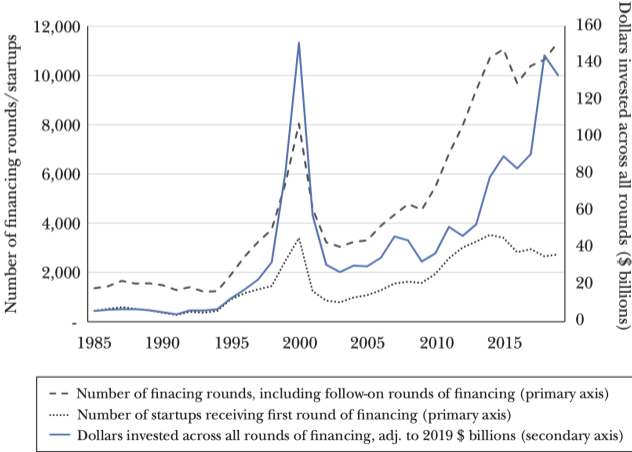


Figure 1 A graphical model of VC.

The growth of the venture capital industry (Lerner and Nanda 2020)

Figure 1
Evolution of the US Venture Capital Industry from 1985–2019



The growth of the venture capital industry (Lerner and Tåg 2013)

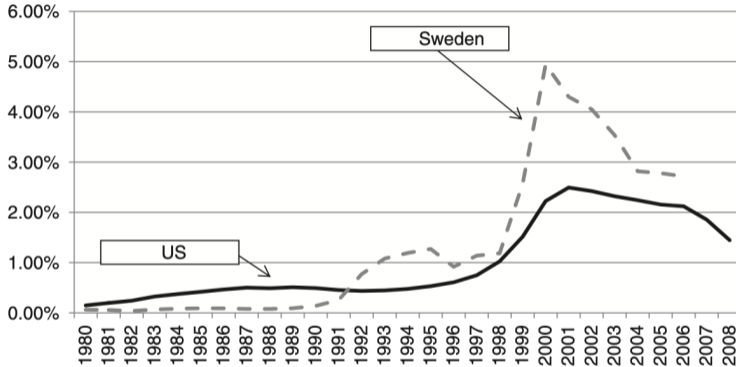


Figure 2 Capital under management by venture capital firms as % of GDP. *Source:* World Bank, Statistics Sweden, Isaksson 2006; EVCA, SVCA and NVCA.

The growth of the venture capital industry (Lerner and Tåg 2013)

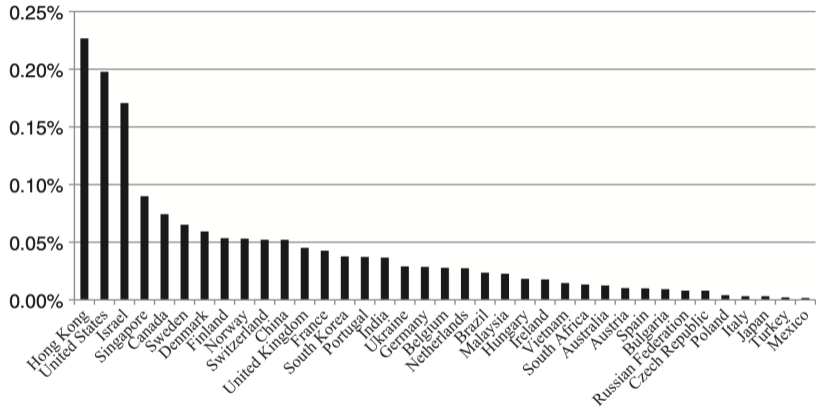


Figure 4 Investments by venture capital firms as % of GDP in 2010. *Source:* VentureXpert; various national VC association yearbooks.

The importance of venture capital (Lerner and Nanda 2020)

Table 1

Comparison of Publicly Traded Firms in the United States, Based on Whether Backed by Institutional Venture Capital Investors

	<i>VC-Backed IPOs</i>	<i>All IPOs</i>	<i>VC-Backed as a % of all</i>
Total number of non-financial IPOs between 1995 and 2019	1,930	4,109	47.0%
Number of firms still public at 12/31/2019	582	1,044	55.7%
Share of IPOs that were still public at 12/31/2019	30%	25%	
<i>Key statistics as of December 31, 2019 for firms still public (all figures millions USD, except number of employees)</i>			
Total enterprise value	4,844,717	7,129,838	67.9%
Total market capitalization	4,922,394	6,462,409	76.2%
Global employees	2,279,715	5,336,394	42.7%
Total revenue	1,157,679	2,171,239	53.3%
Net income	53,082	98,554	53.9%
R&D expenditure	148,388	167,442	88.6%

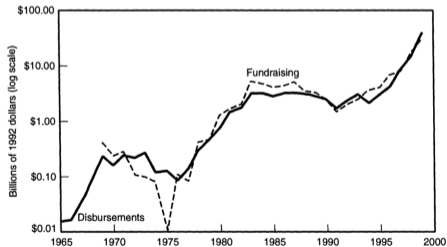
Under 0.5% of new ventures obtain venture capital (Puri and Zarutskie 2012)

Causality vs selection

- Kortum and Lerner (2000) on **patenting and innovation**
 - Study association between VC and patenting (industry level) 1965 and 1992
 - Use the Prudent man rule change in 1979 to ERISA
 - VC was less than 3% of R&D in 1983-1992, but was responsible to 8% of innovation

FIGURE 1

VENTURE CAPITAL FUNDRAISING AND DISBURSEMENTS, 1965-1999



Note: Data on venture capital fundraising are not available prior to 1969. No capital was raised by venture funds in 1975.

Causality vs selection

- Bernstein, Giroud and Townsend (2016) on **monitoring and advice**
- Ideal experiment:
 - Randomly provide some firms with VC funding
 - Randomly vary VC involvement **after** initial investments have been made
 - Allows identification of the VC effect holding selection effects fixed
- Bernstein, Giroud and Townsend (2016):
 - Introduction of **new** airline routes that reduce travel time between VC firms and portfolio companies (mean reduction of 126 minutes)
 - Focus only on introductions after investments have been made
 - Survey: 90% of surveyed VC agreed that direct flights lead to more visits

Causality vs selection

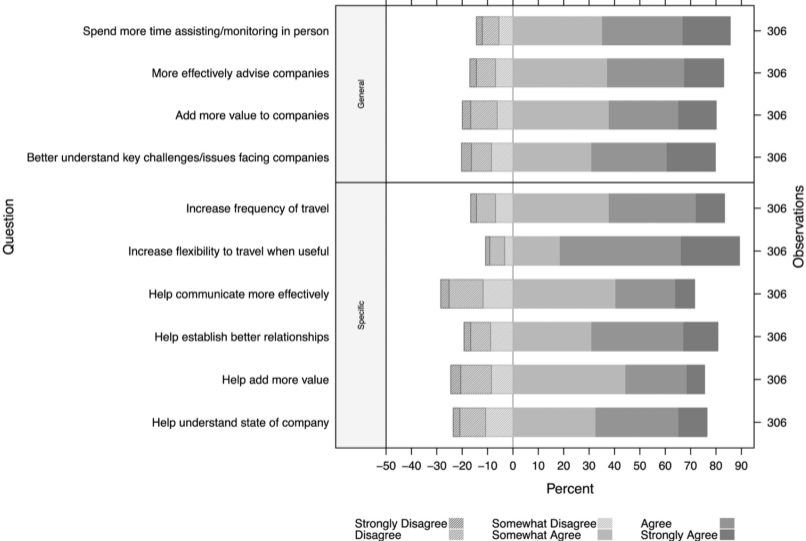
- Empirical model:

$$y_{ijt} = \beta \times \text{Treatment}_{ijt} + \gamma' \mathbf{X}_{ijt} + \alpha_{ij} + \alpha_{MSA(i)} \times \alpha_t + \alpha_{MSA(j)} \times \alpha_t + \epsilon_{ijt} \quad (1)$$

- With:
 - i is portfolio company
 - j is VC firm
 - t is year
 - y is innovation/IPO
 - $Treatment$ is 1 if a new route opened up between i and j

- Thomson Reuters's VentureXpert database
 - detailed information about the dates of venture financing rounds, the investors, and portfolio companies involved, the estimated amounts invested by each party, and the ultimate portfolio company outcome.
 - detailed information on the location of each VC firm and portfolio company
- Innovative output of portfolio companies from the NBER Patent Data Project
- Airline routes are obtained from the T-100 Domestic Segment Database/and ER-586 Service Segment Data

What do venture capitalists say reduced travel times do?



Effects on innovation and exits

Panel A: Innovation						
	Patents			Citations/Patent		
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.0371*** (0.00975)	0.0352*** (0.00971)	0.0310*** (0.0113)	0.0744*** (0.0178)	0.0698*** (0.0178)	0.0575*** (0.0203)
Controls	No	Yes	Yes	No	Yes	Yes
Pair FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	Yes	Yes	No
MSA (VC) × Year FE	No	No	Yes	No	No	Yes
MSA (Company) × Year FE	No	No	Yes	No	No	Yes
R ²	0.638	0.640	0.668	0.546	0.547	0.576
Observations	130,169	130,169	130,169	130,169	130,169	130,169

Panel B: Exits						
	IPO			Success		
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.0103*** (0.00378)	0.00994*** (0.00373)	0.0104** (0.00429)	0.0113** (0.00507)	0.0112** (0.00493)	0.0135** (0.00577)
Controls	No	Yes	Yes	No	Yes	Yes
Pair FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	Yes	Yes	No
MSA (VC) × Year FE	No	No	Yes	No	No	Yes
MSA (Company) × Year FE	No	No	Yes	No	No	Yes
R ²	0.435	0.440	0.494	0.399	0.405	0.453
Observations	130,169	130,169	130,169	130,169	130,169	130,169

- Patents: 3.1-3.7%
- Citations: 5.7-7.4%
- IPO: 1.0%
- Acquisition/IPO: 1.1-1.4%

Venture capital

How do venture capitalists make decisions?

How do venture capitalists make decisions?

- Gompers, Gornall, Kaplan, and Stebulaev 2020:
 - From where do deal opportunities originate?
 - How does the selection process work (stages)?
 - Which are the most important investment criteria?
 - How long does the investment process last?
 - Which quantitative measures are used?

Table 1

Number of VC firm respondents.

Count of the individual survey respondents and the VC firms that they belong to. The first panel looks at all surveys, the second panel looks at our main sample of respondents at institutional VC funds. A firm is counted in a category if at least one respondent at that firm is in that category.

	Respondents		Firms	
	<i>N</i>	%	<i>N</i>	%
Total responses	1110	100	860	100
Respondents at institutional VC firms	885	80	681	79
Respondents in corporate VC	141	13	120	14
Respondents at other investors	84	8	82	10
Sample: Respondents at institutional VC funds				
Total responses	885	100	681	100
Completed surveys	565	64	470	69
Surveys completed on behalf of someone else	11	1	11	2
Respondent is a partner	667	75	552	81
Matched to VentureSource	789	89	589	86

Table 2

Statistics on VC firm respondents.

A number of statistics on our sample of the VC survey respondents. For each measure, we report the number of firms we have that measure for and the across-firm averages, quartiles, and standard deviations. The symbol ^{vs} denotes data from Dow Jones VentureSource.

	N	Mean	Pct 25	Median	Pct 75	Std dev
Fund characteristics						
Fund size (\$m)	557	286	58	120	286	775
Fund size (\$m) ^{vs}	471	370	34	100	253	1335
Vintage year	547	2012	2011	2014	2015	4
Vintage year ^{vs}	477	2010	2008	2012	2014	5
Firm characteristics						
Year founded ^{vs}	508	1998	1994	2000	2005	10
Number of partners	602	4.8	3.0	4.0	5.0	6.1
Number of investments ^{vs}	484	169	28	73	196	261
Average round size (\$m) ^{vs}	467	33	6	11	19	178
% of exited investments IPO ^{vs}	482	12	0	8	20	14
% of investments exited ^{vs}	484	71	58	77	89	22
% US deals ^{vs}	484	66	17	91	100	41
Intend to raise another fund	436	84	100	100	100	36
Previous fund decile	280	7.8	7.0	8.0	9.0	1.9
Previous fund vintage year	329	2007	2005	2008	2011	5

Deal sourcing

Table 3

Sources of investments.

The percentage of deals closed in the past 12 months originating from each source, as reported by our VC survey respondents. Separate statistics are reported for firms with a focus on the early- or late-stage, a focus on IT or healthcare (Health), an above or below median IPO rate, an above median or below median fund sizes, and a location in California (CA), another US state (OthUS), or outside of the US (Fgn). Statistical significance of the differences between subgroup means at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

	All	Stage		Industry		IPO rate		Fund size		Location		
		Early	Late	IT	Health	High	Low	Large	Small	CA	OthUS	Fgn
Inbound from management	10 (1)	12* (1)	7* (2)	10 (1)	13 (2)	11 (2)	10 (1)	10 (1)	10 (1)	10 (2)	9 (1)	11 (2)
Referred by portfolio company	8 (1)	9** (1)	4** (1)	10 (2)	6 (2)	6 (1)	8 (1)	7 (1)	8 (1)	7 (1)	7 (1)	10* (1)
Referred by other investors	20 (1)	22 (2)	17 (3)	21 (2)	18 (3)	21 (2)	20 (2)	18 (2)	21 (2)	18 (2)	22 (2)	18 (2)
Professional network	31 (1)	31 (2)	25 (3)	27 (3)	29 (4)	30 (3)	33 (3)	31 (2)	31 (2)	33 (3)	30 (2)	29 (2)
Proactively self-generated	28 (1)	23*** (2)	42*** (4)	28 (3)	30 (3)	29 (3)	28 (3)	30 (2)	27 (2)	27 (2)	28 (2)	29 (2)
Quantitative sourcing	2 (0)	1 (1)	3 (1)	3 (1)	2 (1)	3* (1)	1* (1)	2 (1)	2 (1)	2 (1)	2 (1)	2 (1)
Number of responses	446	202	72	107	68	114	122	200	246	123	179	160

Deal screening

Table 4

Potential Investments that reach each stage of the deal funnel per closed deal.

The average number of deals that reach each stage of the deal funnel for every closed deal, as reported by our VC survey respondents. Separate statistics are reported for firms with a focus on the early- or late-stage, a focus on IT or healthcare (Health), an above or below median IPO rate, an above median or below median fund sizes, and a location in California (CA), another US state (OthUS), or outside of the US (Fgn). Statistical significance of the differences between subgroup means at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

	All	Stage		Industry		IPO rate		Fund size		Location		
		Early	Late	IT	Health	High	Low	Large	Small	CA	OthUS	Fgn
Considered per close	101 (7)	119 (14)	94 (17)	151** (22)	78** (10)	123 (15)	107 (13)	111 (11)	96 (9)	115 (15)	87 (9)	110 (12)
Met management	28 (3)	34 (7)	24 (3)	50* (13)	20* (3)	45* (11)	23* (2)	37** (6)	21** (2)	46*** (10)	22*** (2)	23 (2)
Reviewed with partners	10 (1)	11 (3)	10 (2)	13 (5)	11 (3)	15* (4)	8* (1)	11 (1)	10 (2)	10 (1)	12 (3)	8 (1)
Exercised due diligence	4.8 (0.3)	4.6 (0.4)	4.4 (0.4)	5.3 (0.6)	5.3 (0.6)	6.3*** (0.7)	4.1*** (0.4)	5.3* (0.4)	4.4* (0.4)	5.2 (0.3)	5.4 (0.5)	3.7*** (0.4)
Offered term sheet	1.7 (0.1)	1.5*** (0.0)	2.3*** (0.2)	1.6 (0.1)	1.6 (0.1)	1.8 (0.1)	1.7 (0.1)	1.7 (0.1)	1.7 (0.1)	1.7 (0.1)	1.8 (0.1)	1.6 (0.1)
Number of responses	442	195	76	106	64	117	119	205	238	125	180	155

Deal screening

Table 5

Important factors for investment selection.

The percentage of our VC survey respondents who report each attribute as important (top) and as the most important (bottom) when deciding whether to invest. Separate statistics are reported for firms with a focus on the early- or late-stage, a focus on IT or healthcare (Health), an above or below median IPO rate, an above median or below median fund sizes, and a location in California (CA), another US state (OthUS), or outside of the US (Fgn). Statistical significance of the differences between subgroup means at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Important factor	All	Stage		Industry		IPO rate		Fund size		Location		
		Early	Late	IT	Health	High	Low	Large	Small	CA	OthUS	Fgn
Team	95 (1)	96 (1)	93 (3)	96 (2)	91 (3)	96 (2)	96 (1)	96 (1)	95 (1)	97 (1)	93 (2)	96 (1)
Business model	83 (2)	84 (2)	86 (4)	85* (3)	75* (4)	79 (3)	82 (3)	83 (2)	82 (2)	83 (3)	84 (2)	81 (3)
Product	74 (2)	81*** (2)	60*** (5)	75 (4)	81 (4)	75 (3)	74 (3)	71* (3)	77* (2)	81** (3)	71** (3)	73 (3)
Market	68 (2)	74 (3)	69 (5)	80*** (3)	56*** (5)	68 (4)	74 (3)	67 (3)	70 (3)	76** (3)	66** (3)	64 (3)
Industry	31 (2)	30 (3)	37 (5)	33** (4)	19** (4)	25 (3)	29 (3)	30 (3)	31 (3)	31 (3)	37 (3)	24*** (3)
Valuation	56 (2)	47*** (3)	74*** (5)	54* (4)	42* (5)	59* (4)	49* (4)	59* (3)	52* (3)	63 (4)	60 (3)	46*** (3)
Ability to add value	46 (2)	44 (3)	54 (5)	41 (4)	45 (5)	39* (4)	48* (4)	41** (3)	51** (3)	46 (4)	48 (3)	46 (3)
Fit	50 (2)	48 (3)	54 (5)	49 (4)	40 (5)	38** (4)	50** (4)	46** (3)	54** (3)	48 (4)	51 (3)	50 (3)

Investment process

Table 6

Investment process questions.

This table summarizes the average responses to a number of questions on VC firm's investment process, as given by our VC survey respondents. Separate averages are reported for firms with a focus on the early- or late-stage, a focus on IT or healthcare (Health), an above or below median IPO rate, an above median or below median fund sizes, and a location in California (CA), another US state (OthUS), or outside of the US (Fgn). Statistical significance of the differences between subgroup means at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

	All	Stage		Industry		IPO rate		Fund size		Location		
		Early	Late	IT	Health	High	Low	Large	Small	CA	OthUS	Fgn
Days to close deal	83 (3)	73*** (3)	106*** (14)	59*** (3)	98*** (5)	83 (8)	83 (4)	80 (5)	86 (3)	65** (8)	83** (3)	96*** (4)
Number of responses	523	223	83	120	84	133	142	231	294	144	206	192
Hours on due diligence	118 (9)	81*** (6)	184*** (39)	76*** (7)	120*** (10)	101 (10)	121 (23)	125 (16)	111 (9)	81** (8)	129** (17)	132 (14)
Number of responses	433	194	68	95	72	116	115	201	232	127	178	144
References called	10 (0)	8*** (0)	13*** (1)	10 (1)	11 (1)	12 (1)	11 (1)	12*** (1)	9*** (0)	11 (1)	11 (1)	9** (1)
Number of responses	439	195	70	100	71	117	116	204	235	126	180	150

Financial metrics

Table 7

Financial metrics used to analyze investments.

The percentage of our VC survey respondents who use each financial metric to analyze investments as well as the average required IRR and MOIC these respondents report using. Separate statistics are reported for firms with a focus on the early- or late-stage, a focus on IT or healthcare (Health), an above or below median IPO rate, an above median or below median fund sizes, and a location in California (CA), another US state (OthUS), or outside of the US (Fgn). Statistical significance of the differences between subgroup means at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

	All	Stage		Industry		IPO rate		Fund size		Location		
		Early	Late	IT	Health	High	Low	Large	Small	CA	OthUS	Fgn
None	9 (1)	17*** (2)	1*** (1)	13 (3)	7 (3)	10 (2)	12 (2)	9 (2)	10 (2)	11 (2)	8 (2)	10 (2)
Multiple of invested capital	63 (2)	56*** (3)	71*** (5)	57** (4)	72** (5)	72* (3)	63* (4)	65 (3)	61 (3)	66 (4)	66 (3)	58** (3)
IRR	42 (2)	26*** (3)	60*** (5)	33 (4)	42 (5)	35 (4)	36 (4)	40 (3)	42 (3)	31*** (3)	49*** (4)	42 (3)
NPV	22 (2)	12** (2)	21** (4)	16** (3)	29** (5)	19 (3)	16 (3)	24 (3)	21 (2)	16 (3)	20 (3)	29*** (3)
Other	8 (1)	9 (2)	4 (2)	7 (2)	10 (3)	8 (2)	8 (2)	8 (2)	7 (1)	9 (2)	6 (2)	9 (2)
Number of metrics	2.1 (0.0)	1.8*** (0.1)	2.4*** (0.1)	2.0 (0.1)	2.0 (0.1)	2.0 (0.1)	2.0 (0.1)	2.1 (0.1)	2.0 (0.1)	2.0 (0.1)	2.1 (0.1)	2.1 (0.1)
Number of responses	546	238	90	130	88	136	152	243	306	156	217	195
Often make gut investment decisions	44 (2)	48* (3)	37* (5)	45* (4)	34* (5)	42 (4)	43 (4)	40* (3)	47* (3)	41 (4)	41 (3)	49** (3)
Number of responses	563	243	91	132	88	140	158	251	315	162	221	202
Quantitatively analyze past investments	11 (1)	12 (2)	8 (3)	11 (3)	16 (4)	15 (3)	11 (3)	11 (2)	11 (2)	12 (3)	9 (2)	13 (3)
Number of responses	488	213	82	115	76	127	138	228	263	140	199	169
Average required IRR	31 (1)	33* (2)	29* (1)	34 (2)	33 (2)	30 (2)	30 (2)	28*** (1)	33*** (1)	31 (2)	30 (1)	31 (1)
Number of responses	216	58	49	41	35	48	52	99	114	48	93	79

Financial forecasting

Table 9

Forecasting period.

The percentage of our VC survey respondents who report forecasting portfolio company financials for each time period. Separate statistics are reported for firms with a focus on the early- or late-stage, a focus on IT or healthcare (Health), an above or below median IPO rate, an above median or below median fund sizes, and a location in California (CA), another US state (OthUS), or outside of the US (Fgn). Statistical significance of the differences between subgroup means at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

	All	Stage		Industry		IPO rate		Fund size		Location		
		Early	Late	IT	Health	High	Low	Large	Small	CA	OthUS	Fgn
Do not forecast	20 (2)	31*** (3)	7*** (3)	22 (4)	29 (5)	19 (3)	17 (3)	17** (2)	24** (2)	24 (3)	20 (3)	18 (3)
1-2 years	11 (1)	14 (2)	8 (3)	20** (4)	8** (3)	12 (3)	12 (3)	9 (2)	11 (2)	12 (3)	9 (2)	12 (2)
3-4 years	40 (2)	38 (3)	39 (5)	41* (4)	28* (5)	38 (4)	43 (4)	44* (3)	36* (3)	38 (4)	36 (3)	44* (3)
5-6 years	27 (2)	16*** (2)	42*** (5)	16* (3)	27* (5)	28 (4)	25 (3)	27 (3)	27 (3)	24** (3)	34** (3)	21** (3)
7+ years	3 (1)	1** (1)	5** (2)	1*** (0)	8*** (3)	4 (1)	2 (1)	3 (1)	2 (1)	2 (1)	1 (1)	5** (2)
Average	3.1 (0.1)	2.4*** (0.1)	3.9*** (0.2)	2.5** (0.2)	3.2** (0.3)	3.2 (0.2)	3.0 (0.1)	3.2 (0.1)	2.9 (0.1)	2.8 (0.2)	3.1 (0.1)	3.2 (0.2)
Number of responses	530	225	90	123	82	131	146	237	295	149	211	191
% of companies which meet projections	28 (1)	26*** (1)	33*** (2)	28 (2)	28 (2)	28** (2)	23** (1)	31*** (1)	26*** (1)	28 (2)	27 (1)	29 (1)
Number of responses	493	214	82	115	77	126	129	228	264	141	195	176

Venture capital

Venture capital and experimentation

Entrepreneurship as experimentation (Kerr, Nanda, Rhodes-Kropf 2014)

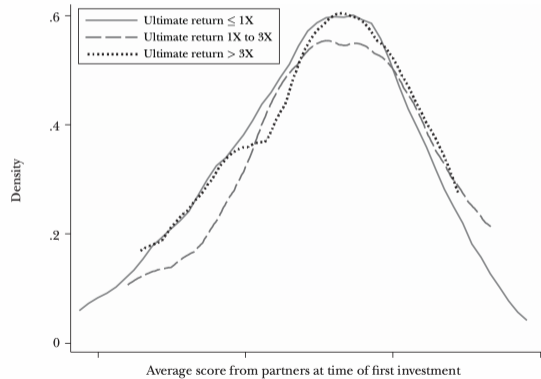
- Entrepreneurship is fundamentally about **experimentation**
 - Knowledge required to be successful is hard to know in advance.
 - Example: Sequoia's investment (12.5m to 4B) in Google that many VCs passed on (Bessemer partners: "how can I get out of this house without going anywhere near your garage?")
 - Entrepreneurship involves true uncertainty, not only risk with known probabilities and outcomes (Knight 1921)
 - Return distribution has low median, but high variance
 - Even top professionals cannot predict which startups success (1B USD over 10y)

Entrepreneurship as experimentation

Figure 2

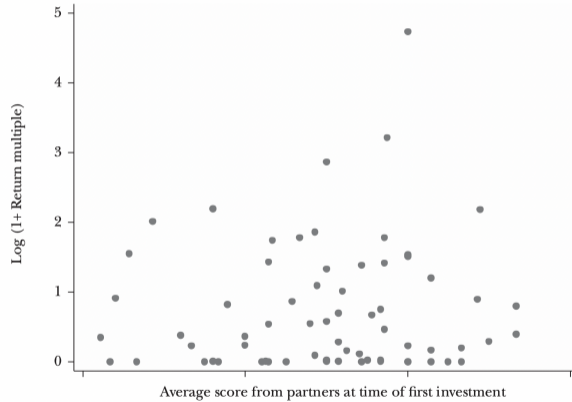
Scores Assigned to Investments at Time of First Investment and the Ultimate Returns of Those Investments, for One Venture Capital Firm

A: Distribution of Scores by Outcome



Entrepreneurship as experimentation

B: Correlation between Scores and Outcomes



The process of experimentation

- Experimentation allows entrepreneurs/investors to **learn** about viability
- Investment project
 - Investment cost to commercialize: 110 EUR
 - Worth 0 with probability 99% and 10 000 EUR with probability 1%
 - Expected value: -10 EUR
- Suppose:
 - Entrepreneur/investor can pay X EUR to know if the probability of success is 10% instead of 1%
 - Yes: Expected value is now $1000 \text{ EUR} - 110 \text{ EUR} = 890 \text{ EUR}$
 - No: Expected value: -10 EUR
 - Worth paying $X < 89 \text{ EUR}$ (10% of 890 EUR) to learn about viability

The process of experimentation and venture capital

- Experimentation:
 - Tests that resolve uncertainty and creates a **real option value**
 - Useful when initial information is highly valuable
 - Useful when costs to learn about viability are low (for investor AND entrepreneur)
- Venture capital funds:
 - A portfolio of tests across a number of highly **uncertain** ideas with skewed economics
 - Once a test is positive: the VC fund invests aggressively (compare to example above)
 - Needs to **invest early** to be able to later **invest aggressively**
 - Thus VC use **staging** to invest in projects with **low experimentation costs** and **potential for aggressive scaling**
- Compared to mutual funds that provide **diversification** and not need to invest first to have access later

Frictions in the experimentation process

- **Cost-related frictions**

- Open source/cloud computing has lowered costs from 5M to 50K in a decade
- Lean startups and "minimum viable products"
- Crowdfunding, accelerators, and angel groups have boomed as capital requirements went down
- However: costs affect industry focus of VC firms

- **Organizational frictions**

- Key to be able to terminate projects (don't "throw good money after bad")
- Best VC funds tend to have high termination rates
- Difficult to terminate projects in large firms due to soft budget constraints and career concerns
- Outside evaluation can help (co-investments, tenure process ect)
- "Tolerance for failure" important at all levels (individual, firm society)

Frictions in the experimentation process

- **Continuation and financing frictions**
 - Financing risk: cyclical in VC funding means that money might not be available when needed for scaling
 - Taking on larger investments (longer "runways") means financing risk is lower, but abandonment is harder
 - Note: most innovative firms may **need** "hot markets" to drive initial commercialization
- **Institutional frictions**
 - Democratizing entry and facilitating efficient failure
 - Bankruptcy law and limited liability can encourage experimentation
 - Strong employment protection laws limit firms ability to adjust scale and pivot
 - Property rights, rule of law, public equity markets, and appropriate taxes allows capitalizing on success

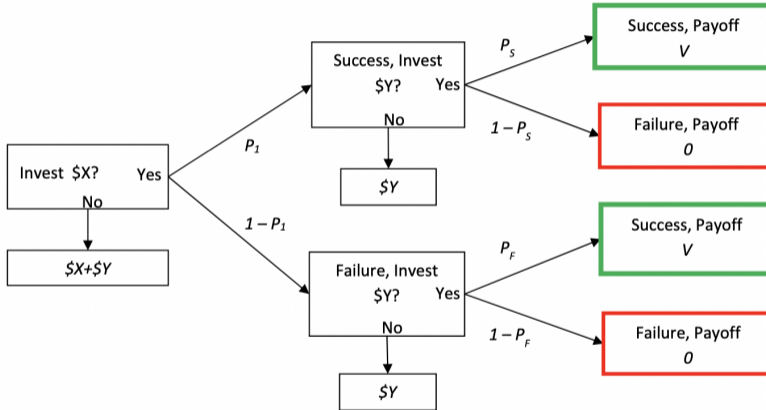
Summary: the process of experimentation

- Experimentation allows entrepreneurs/investors to **learn** about viability
- Venture capital funds:
 - A portfolio of tests across a number of highly uncertain ideas with skewed economics
 - Once a test is positive: the VC fund invests aggressively (compare to example above)
 - Needs to invest early to be able to later invest aggressively
 - Thus VC use staging to invest in projects with low experimentation costs and potential for aggressive scaling
- Several frictions:
 - Cost
 - Organization
 - Continuation
 - Institutional

Cost of Experimentation and the Evolution of Venture Capital

- Ewens, Nanda and Rhodes-Kropf (2018)
 - Documents how the VC industry have evolved as a result of **technological shocks**
 - Technology lowered costs of experimentation
 - VC funds started to implement "spray and pray": little funding **and** governance
 - Shift in the focus of the VC industry
- Amazon Web Services (2006)
 - Introduced ability to rent hardware in small increments (up front fixed costs became variable costs)
 - Lowered start-up and scaling costs
 - Lowered scaling costs
 - Example: Dropbox ran 2007-2015 on AWS, now has own servers

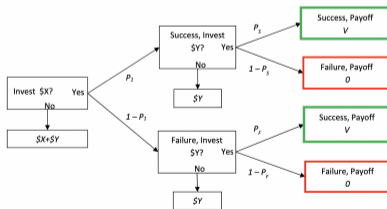
Cost of Experimentation and the Evolution of Venture Capital



VC will only invest if $p_1(p_S V - Y) - X > 0$ supposing that $p_F V < Y$

Cost of Experimentation and the Evolution of Venture Capital

- VC will only invest if $p_1(p_s V - Y) - X > 0$. If X falls, then:
 - VC firms make more investments (expression above is more likely to hold)
 - If partners are limited, then less governance per investment
 - Marginal venture of "lower quality" (V is lower)
 - Marginal venture is "riskier" (p_1 is lower)

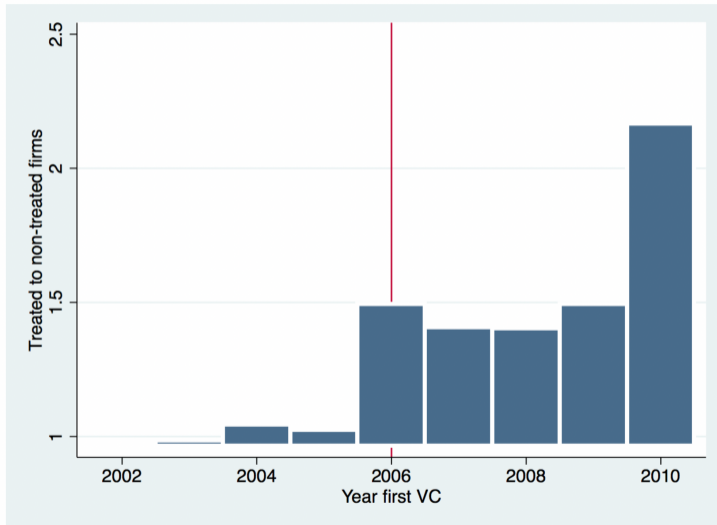


Cost of Experimentation and the Evolution of Venture Capital

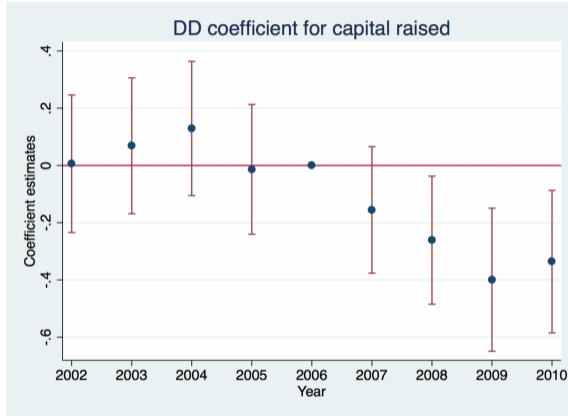
- Data:
 - Correlation Ventures, VentureEconomics and VentureSource
 - First round investments between 2002 and 2010
 - About 9000 firms financed by 2800 unique investors
- Empirical design:
 - Difference-in-Differences
 - AWS introduction in 2006 = "After"
 - Narrow industry exposure to AWS = "Treated"

$$Y_{jit} = \beta_1 \text{Treated}_i * \text{Post}_t + \beta_2 X_i + \gamma_t + \rho_j + \nu_{jit} \quad (2)$$

Ratio of investments (treated/control)



DiD: Capital raised



Initial capital invested is 15-27% lower or 670k to 1300k USD lower

Log total investments in quarter industry

	Log total investments in quarter-industry			
	All VCs (1)	All VCs (2)	“Active” VCs (3)	“Active” VCs (4)
Treated X Post-2005	0.0277*** (0.00772)	0.0412*** (0.00850)	0.0453*** (0.0117)	0.0506*** (0.0113)
Treated	0.0136** (0.00585)	0.0152** (0.00688)	0.0140** (0.00642)	0.0158** (0.00754)
Observations	30340	30340	17066	17066
Number VCs	2813	2813	506	506
R^2	0.0254	0.0215	0.0296	0.0230
Industry FE?	N	N	N	N
Year FE?	Y	Y	Y	Y
VC firm FE?	N	Y	N	Y

Active: at least 3 investments in pre-period

Increase is 1.5 investments per firm out of a mean of 10-15 investments

Governance through board seats

	All VCs (1)	All VCs (2)	“Active” VCs (3)	“Active” VCs (4)
Treated X Post-2005	-0.0266 (0.0171)	-0.0301 (0.0188)	-0.0616** (0.0251)	-0.0534** (0.0268)
Treated	0.0159 (0.0181)	0.000412 (0.0177)	0.0584** (0.0232)	0.0252 (0.0251)
Syndicate size	0.0856*** (0.00377)	0.0642*** (0.00394)	0.105*** (0.00554)	0.0750*** (0.00541)
Startup based in CA	0.0426*** (0.0120)	0.00598 (0.00953)	0.0587*** (0.0189)	0.0110 (0.0164)
Startup based in MA	0.0617*** (0.0167)	0.0425** (0.0199)	0.0682*** (0.0232)	0.0554** (0.0273)
Startup based in NY	0.0511*** (0.0166)	0.0266 (0.0170)	0.0737** (0.0329)	0.0271 (0.0316)
Observations	10250	10250	4760	4760
Number startups	5913	5913	3461	3461
Number VCs	2158	2158	500	500
R^2	0.105	0.0693	0.127	0.0752
Industry FE?	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y
VC firm FE?	N	Y	N	Y

14-21% lower probability of board seat

Quality through founder age and serial entrepreneurship

	Log founding team age		Serial entrepreneur?	
	All VCs (1)	“Active” VCs (2)	All VCs (3)	“Active” VCs (4)
Treated X Post-2005	-0.0519*** (0.0103)	-0.0441*** (0.0101)	-0.0431** (0.0177)	-0.0505** (0.0233)
Treated	-0.0348*** (0.00689)	-0.0373*** (0.00869)	0.0887*** (0.0143)	0.0916*** (0.0190)
Startup based in CA	-0.0485*** (0.00660)	-0.0487*** (0.00730)	0.0730*** (0.0133)	0.0617*** (0.0156)
Startup based in MA	-0.00954 (0.00652)	-0.0142 (0.00924)	0.0538*** (0.0190)	0.0651** (0.0291)
Startup based in NY	-0.0654*** (0.00957)	-0.0806*** (0.0166)	0.0136 (0.0172)	-0.0285 (0.0263)
Observations	11201	5623	15266	7589
Number startups	5717	3727	7902	5042
Number VCs	2171	500	2594	505
R^2	0.103	0.0965	0.0141	0.0143
Industry FE?	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y
VC firm FE?	Y	Y	Y	Y

Note: no sign of increased governance

Failure through follow on investments or failed by end of sample

	Follow on?		Failed?	
	All VCs (1)	“Active” VCs (2)	All VCs (3)	“Active” VCs (4)
Treated X Post-2005	-0.0193 (0.0169)	-0.0518** (0.0231)	0.0117 (0.0200)	0.0535** (0.0238)
Treated	0.0486*** (0.0140)	0.0516*** (0.0190)	-0.125*** (0.0145)	-0.137*** (0.0200)
Startup based in CA	0.0434** (0.0173)	0.0230 (0.0153)	-0.0528*** (0.0161)	-0.0348** (0.0158)
Startup based in MA	0.0384** (0.0180)	0.0261 (0.0195)	-0.0686*** (0.0162)	-0.0599*** (0.0218)
Startup based in NY	0.0462** (0.0219)	0.0513* (0.0309)	-0.0172 (0.0204)	0.0207 (0.0320)
Observations	16940	8332	16940	8332
Number startups	8960	5617	8960	5617
Number VCs	2815	506	2815	506
R^2	0.00550	0.00590	0.0149	0.0137
Industry FE?	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y
VC firm FE?	Y	Y	Y	Y

Conditional on success, later investments are larger

	Step up in valuation round 1 to round 2		Log exit value to capital raised (non-failed)	
	All VCs (1)	“Active” VCs (2)	All VCs (3)	“Active” VCs (4)
Treated X Post-2005	0.195*** (0.0722)	0.230** (0.0902)	0.217 (0.139)	0.355** (0.167)
Treated	-0.0408 (0.0452)	-0.0657 (0.0552)	0.239* (0.129)	0.146 (0.154)
Startup based in CA	0.125** (0.0627)	0.0400 (0.0636)	-0.132* (0.0792)	-0.0740 (0.124)
Startup based in MA	-0.0448 (0.0906)	-0.115 (0.0818)	-0.238** (0.108)	-0.184 (0.148)
Startup based in NY	0.0235 (0.0703)	-0.0181 (0.111)	-0.208* (0.119)	-0.166 (0.236)
Observations	2442	1373	2488	1438
Number startups	1066	802	1133	832
Number VCs	806	343	837	368
R^2	0.0440	0.0535	0.0336	0.0409
Industry FE?	Y	Y	Y	Y
Year FE?	Y	Y	Y	Y
VC firm FE?	Y	Y	Y	Y

Cost of Experimentation and the Evolution of Venture Capital

- Ewens, Nanda and Rhodes-Kropf (2018)
 - Documents how the VC industry have evolved as a result of **technological shocks**
 - Technology lowered costs of experimentation
 - Amazon Web Services (2006)
- Shows:
 - More investments
 - Lower invested amounts in first round
 - Fewer board seats (less governance)
 - Lower quality (founder age and experience)
 - Faster scaling conditional on initial success
- Note: new intermediaries enter as costs fall (accelerators, angel groups etc)

Venture capital

Limitations of venture capital

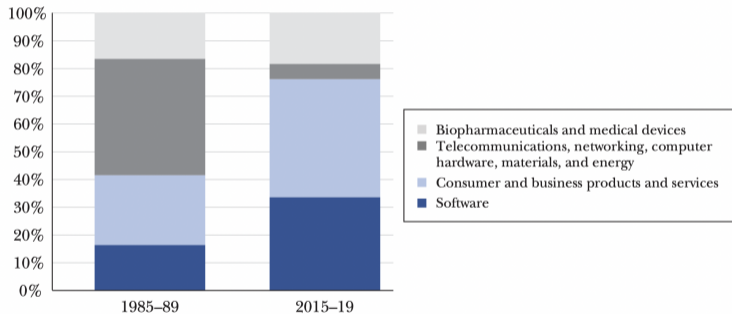
Limitations of venture capital

- Some issues (Lerner and Nanda 2020)
 1. A declining emphasis of governance (or not)
 - "Pray and Spray"
 - Increase in founder-friendly terms
 - Conditions, however, are different now
 2. Optimized for a narrow slice of tech innovation
 3. Highly concentrated in financial and human capital

Optimized for a narrow slice of tech innovation

Figure 2

Venture Capital Investment into US Startups between 1985 and 2019, by Sector



Top ten patent classes represent 48% of all classes for VC patents (24 for non-VC)

Highly concentrated in financial and human capital

Characteristics of Key US-based Investment Professionals in the 50 Largest Venture Capital Firms

	<i>US-based partners</i>	<i>US-based partners with at least one board seat</i>
Total number of Partners	416	265
Share male	82%	92%
Share attended top universities	59%	72%
Share with MBA from Harvard	12%	15%
Share with MBA from Stanford	9%	13%
Share located in Bay Area	69%	69%
Share located in Greater Boston	9%	11%
Share located in New York City	14%	11%
Average number of board seats held		6.1
Median number of board seats held		5

Top 50 firms (5% of all firms) raised 50% of all capital 2014-2018
Risks "hollowing out" of non-tech clusters and discrimination against founders

Venture capital

The growth and impact of the venture capital industry

How do venture capitalists make decisions?

Venture capital and experimentation

Limitations of venture capital