Investment Cycles and Startup Innovation

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CEPR Workshop 2015 –
Moving to the Innovation Frontier

Failure and Success

Only those who dare to fail greatly can ever achieve greatly. - Robert Kennedy

Funding of innovation requires more than capital…
- In VC 85% of returns come from 10% of investments.
- 50% of venture backed companies fail
- 13% of investment have achieved an IPO since 1987.

Failure may be central to the funding of innovation…

Our willingness to fail gives us the ability and opportunity to succeed where others may fear to tread. - Vinod Khosla

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Ex. of the extreme distribution

- Sequoia Capital placed a bet in 1999 on an early-stage startup called Google, that purported to have a better search algorithm.
  - Sequoia's $12.5 million investment was worth $4 billion when it sold in 2005. 320x!

- Not obvious – could have been another "me too"
  - David Cowan when asked to meet the founders famously quipped "Students? A new search engine? How can I get out of the house without going anywhere near your garage?"

Exante Bad or Good Not obvious

BVP had the opportunity to invest in pre-IPO secondary stock in Apple at a $60M valuation. BVP's Neill Brownstein called it "outrageously expensive."

"Stamps? Coins? Comic books? You've GOT to be kidding," thought Cowan. "No-brainer pass."

Incredibly, BVP passed on Federal Express seven times.

Cowan's college friend rented her garage to Sergey and Larry for their first year. In 1999 and 2000 she tried to introduce Cowan to "these two really smart Stanford students writing a search engine". Students? A new search engine? In the most important moment ever for Bessemer's anti-portfolio, Cowan asked her, "How can I get out of this house without going anywhere near your garage?"

Easier to tell they were risky

intel BVP's Pete Bancroft never quite settled on terms with Bob Noyce, who instead took venture financing from a guy named Arthur Rock.

Intuit. Along with every venture capitalist on Sand Hill Road, Neill Brownstein turned down Intuit founder Scott Cook. Scott managed to scrape together only $225K from friends, including HBS classmate and Sierra Ventures founder Peter Wendell, who personally invested $25K to get Scott off his back.

Lotus. COMPAQ Ben Rosen, one of the founders of Sevin Rosen, offered Felda Hardymon the chance to invest in both Lotus and Compaq Computer on the same day. Says Hardymon: "Lotus wasn't proven yet, and I was worried about the situation there. As for Compaq, I told him there was no real future in transportable computers since IBM could do it."

PayPal David Cowan passed on the Series A round. Rookie team, regulatory nightmare, and, 4 years later, a $1.5 billion acquisition by eBay.
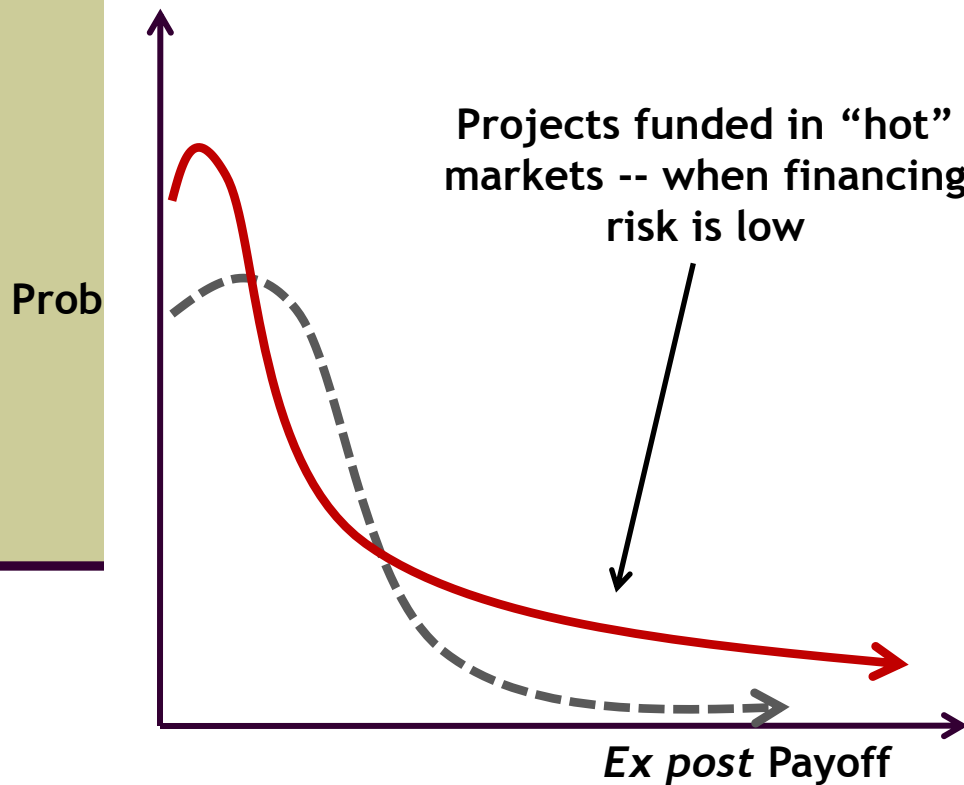
Capital Cycles

- Another feature of the innovation market are the extreme capital cycles.

- Well known and well documented in venture capital...
  - Gompers and Lerner (2004), Kaplan and Schoar (2005), Gompers, Kovner, Lerner and Scharfstein (2008).

- Conventional wisdom and much or the popular literature associate hot periods with low quality ideas being funded.
  - Herding (Scharfstein and Stein, 1990)
  - Fall in investor discipline
  - Lower discount rates

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Experimentation waves?

- Are there times when investors are more willing to experiment?

- We suggest that increased $ leads to increased experimentation. Note that increased experimentation would also be associated with increased failure.

- Understanding the links between these investment cycles and the commercialization of new technologies is a central issue for both academics and policy makers given the importance of innovation.

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Difference between greater experimentation and "worse projects" being funded

Experimentation

Worse Projects

Prob

Projects funded in "hot" markets -- when financing risk is low

Ex post Payoff

Ex post Payoff
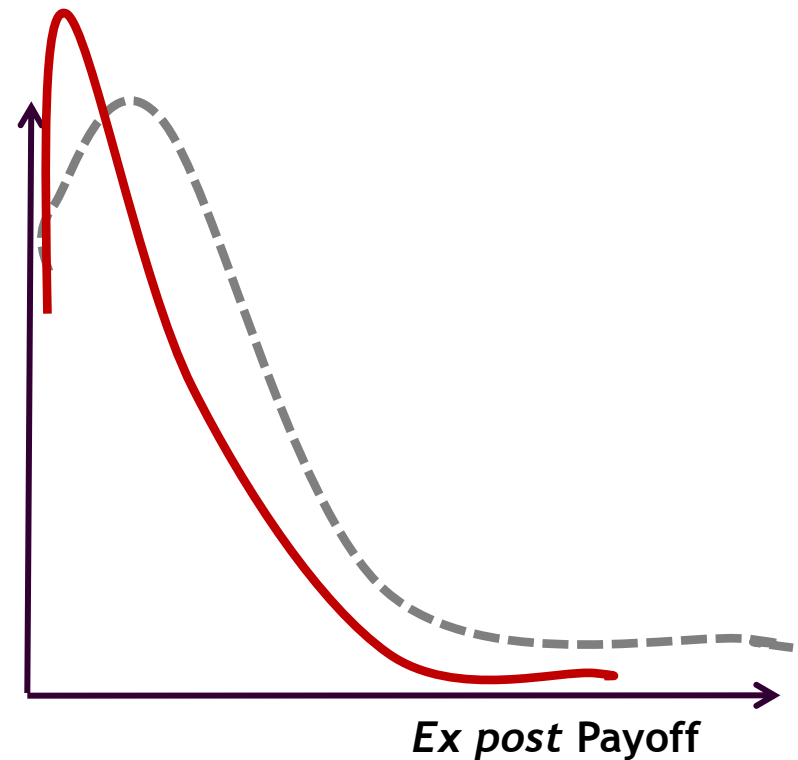
Which matches the data? Mechanism?

Data

- Round-level data on venture financings from 1985 to 2012

  - Dow Jones Venture Source and Venture Economics

  - Our sample focuses on first financings between 1985 and 2004

    - Follow the firms till IPO, acquisition or bankruptcy (truncate at 2004 to give sufficient time to realize outcomes)

    - Look at first financings – where financing risk is likely to be greatest. For comparability focus on early stage first financings

- Key variable: log number of first financing events in a given quarter

In 'hot' times when lots of projects get funding are projects just worse (or better) or are they fundamentally different – more experimental?

ARE PROJECTS JUST WORSE (OR BETTER) IN 'HOT' TIMES?

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Probability of failure based on market when the startup received first funding

	(1)	(2)	(3)	(4)	(5)
		1985-2004			Drop 98-'00
	(1)	(2)	(3)	(4)	(5)
log of number firms financed in that quarter	0.094*** (0.008)	0.102*** (0.007)	0.097*** (0.007)	0.137*** (0.010)	0.057*** (0.020)
Log $ raised by firm in its first financing		-0.028*** (0.008)	-0.032*** (0.008)	-0.026*** (0.007)	-0.039*** (0.007)
Firm Age at first financing		-0.003** (0.001)	-0.003** (0.001)	-0.003*** (0.001)	-0.003** (0.001)
Number of investors in syndicate		0.009*** (0.003)	0.009*** (0.003)	0.007** (0.003)	0.005 (0.004)
Startup based in California		0.020** (0.008)	0.019** (0.008)	0.019** (0.008)	0.005 (0.009)
Startup based in Massachusetts		-0.034** (0.016)	-0.028* (0.016)	-0.029* (0.016)	-0.021 (0.015)
Industry Fixed Effects	No	No	Yes	Yes	Yes
Period Fixed Effects	No	No	No	Yes	Yes
Number of observations	12,285	11,497	11,497	11,497	6,518
R-Squared	0.07	0.08	0.09	0.13	0.08

Robust Standard Errors - Clustered by Quarter

Pre-Money Valuation at IPO

Variable	(1)	(2)	(3)	(4)	Drop if funding year is 1998-2000 (5)
			1985-2004		
Log number of firms financed in quarter	0.792*** (0.082)	0.413*** (0.065)	0.244*** (0.045)	0.214*** (0.051)	0.225*** (0.067)
Log firm's revenue at IPO		0.161*** (0.014)	0.157*** (0.013)	0.129*** (0.014)	0.125*** (0.016)
Firm's age at IPO		-0.025*** (0.007)	-0.016*** (0.006)	-0.015*** (0.005)	-0.016*** (0.006)
Log total funds raised prior to IPO		0.454*** (0.029)	0.382*** (0.028)	0.390*** (0.027)	0.405*** (0.031)
Startup based in California		0.179*** (0.050)	0.157*** (0.044)	0.115** (0.045)	0.110** (0.049)
Startup based in Massachusetts		0.078 (0.075)	0.121* (0.064)	0.085 (0.066)	0.055 (0.062)
Log value of NASDAQ on day of IPO			0.857** (0.381)	0.888** (0.389)	0.586 (0.399)
IPO year fixed effects	No	No	Yes	Yes	Yes
Industry fixed effects	No	No	No	Yes	Yes
Number of observations	1,216	1,197	1,197	1,197	977
R-squared	0.27	0.51	0.63	0.65	0.65

Robust Standard Errors - Clustered by Quarter

Is the relationship because funds change how they invest or because the mix of investors changes?

WITHIN OR ACROSS FUNDS?

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Funding Environment and Startup Outcome - Investor Fixed Effects

	Probability of Failure			Pre-Money Value conditional on IPO		
	All Investors	VCs with ≥ 5 investments in prior two years	VCs with < 5 investments in prior two years	All Investors	VCs with ≥ 5 investments in prior two years	VCs with < 5 investments in prior two years
	(1)	(2)	(3)	(4)	(5)	(6)
log of # of firms financed in quarter	0.134***	0.130***	0.139***	0.158**	0.233***	0.049
	(0.011)	(0.014)	(0.012)	(0.069)	(0.082)	(0.090)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Investor Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	22,011	8,663	13,348	2,959	1,407	1,552
R-Squared	0.22	0.15	0.19	0.77	0.72	0.89

Robust Standard Errors - Clustered by Quarter

Is the relationship only because investment follows innovation or because increased capital causes the type of investment to be more innovative?

POTENTIALLY CAUSED BY "EXCESS CAPITAL"?

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Instrumental Variables

- The pattern is interesting but we would like to know is it because the investment opportunities are different in hot markets, or risk preferences are changing, or because money *changes* the deals done?

- We want a variable that leads to "excess money" but that is unrelated to investment opportunities

  - Instrument: Log of dollars raised by buyout funds in the 5-8 quarters before the firm was funded.
  - Investments into both Buyout and early stage VC are greatly influence by asset allocation decisions to PE unrelated to individual opportunities sets.
  - Our instrument is useful to the extent that flows into Buyout funds do not systematically forecast changing risk preferences two years later or the variability of early stage innovative discoveries two years later.

The Effect of Increased Capital at time of funding on Firm Outcomes

	Probability of Failure		Pre-Money Value conditional on IPO	
	OLS (Col (4) in Table 3)	IV	OLS (Col (4) in Table 4)	IV
	(1)	(2)	(3)	(4)
log of number firms financed in that quarter	0.137***	0.151***	0.214***	0.461**
	(0.010)	(0.030)	(0.051)	(0.107)
Control Variables	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
R-squared	0.13	0.12	0.62	0.61
Number of observations	11,497	11,497	1,197	1,197
Coefficient on Instrument and First Stage Statistics				
Log dollars raise by buyout funds closed 5-8 Quarters before firm funded		0.473***		0.360***
		(0.119)		(0.077)
Partial R-squared		0.171		0.1997
F-Statistic		15.67		21.09

Robust Standard Errors - Clustered by Quarter

The Effect of Increased Capital - Investor Fixed Effects

	Probability of Failure		Pre-Money Value conditional on IPO	
	OLS (Col (2) in Table 5)	IV	OLS (Col (5) in Table 5)	IV
	(1)	(2)	(3)	(4)
log of number firms financed in that quarter	0.134***	0.158***	0.158***	0.311***
	(0.011)	(0.034)	(0.069)	(0.118)
Control Variables	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Investor Fixed Effects	Yes	Yes	Yes	Yes
Number of observations	22,011	22,011	2,959	2,959
R-Squared	0.22	0.21	0.77	0.77
Coefficient on Instrument and First Stage Statistics				
Log dollars raise by buyout funds closed 5-8 Quarters before firm funded		0.013***		0.007***
		(0.003)		(0.003)
Partial R-squared		0.220		0.163
F-Statistic		19.22		23.53

Robust Standard Errors - Clustered by Quarter

Financing Risk: There may be limited future capital

- Why not just give the project more money to protect against financing risk?

- Inherent uncertainty in innovative projects => Staged Investment.
  - Gompers (1995), Bergemann and Hege (2005), Bergemann et al (2008).

- Tradeoff
  - Reduce financing risk
    - Give project more upfront funding
  - Maximize real option value
    - Give project little money to "wait and see"

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Is the relationship because more innovative projects happen in good times or just riskier projects?

INNOVATION OR RISK?

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Funding Environment and Startup Innovation

	Level of Patenting		Citations to patents	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
log of number firms financed in that quarter	0.219***	0.228***	0.156***	0.172**
	(0.055)	(0.088)	(0.054)	(0.086)
Control Variables	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Period Fixed Effects	Yes	Yes	Yes	Yes
R-squared	0.18	0.17	0.10	0.11
Number of observations	1,197	1,197	1,197	1,197

Coefficient on Instrument and First Stage Statistics

Log dollars raise by buyout funds closed 5-8 Quarters before firm funded		0.519***		0.519***
		(0.094)		(0.094)
Partial R-squared		0.359		0.359
F-Statistic		30.45		30.45

Robust Standard Errors - Clustered by Quarter

Innovation – Investors Fixed Effects

	Level of patenting		Citations to patents	
	OLS	IV	OLS	IV
Variable	(1)	(2)	(3)	(4)
Log number of firms financed in the same quarter	0.182**	0.239***	0.161**	0.202**
	(0.069)	(0.097)	(0.076)	(0.098)
Control variables	Yes	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Investor fixed effects	Yes	Yes	Yes	Yes
Number of observations	2,959	2,959	2,959	2,959
R-Squared	0.29	0.28	0.32	0.23

Coefficient on Instrument and First Stage Statistics

Log dollars raised by buyout funds 5-8 quarters before firm funded		0.467***		0.467***
		(0.091)		(0.091)
Partial R-squared		0.324		0.324
F-statistic		26.51		26.51

Robust Standard Errors - Clustered by Quarter

Ex ante Differences at First Funding

Variable	Startup's age at first funding		Syndicate size at first funding	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Log number of firms financed in the same quarter	-0.148***	-0.295***	-0.030***	-0.108***
	(0.030)	(0.077)	(0.009)	(0.025)
Control variables	Yes	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Investor fixed effects	Yes	Yes	Yes	Yes
Number of observations	22,011	22,011	22,011	22,011
R-squared	0.28	0.27	0.46	0.46

Coefficient on Instrument and First Stage Statistics

Log dollars raised by buyout funds 5-8 quarters before firm funded		0.416***		0.425***
		(0.107)		(0.112)
Partial R-squared		0.150		0.150
F-statistic		15.12		14.47

Robust Standard Errors - Clustered by Quarter

Implications

- Money drives innovation
  - Areas with less money directed toward innovation may not simply fund less innovation but dramatically less innovation
    - There is a coordination problem among investors

  - Policies directed toward concentrating money in an area may be important for commercializing innovation

  - Be cautious in popping or stopping "bubbles" around innovative activity.

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More Implications

- Conventional wisdom (and most other work) suggest that contrarian strategies should be good
  - Sell when others are greed and buy when others are fearful.

- This may be backward for the funding of radical innovation.
  - Abundance of capital lowers financing risk and allows experimentation.
  - Angel investors that herd into innovative areas maybe exactly what is needed!

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Summary

- Conventional wisdom suggests weak investments are done at the top of the cycle.
  - We find more experimental investments.
  - Active times have more failure but larger success and greater innovation.

- Conventional wisdom suggests money chases deals.
  - We find money also *changes* deals.
  - Increased funding causes higher failure but greater value if successful and increased patenting with more cites.

- Large effects even for most experienced VC funds.

Valuation Conditional on all exits above $50M

Variable	Pre-money value on exits > $ 50 million	
	OLS	IV
	(1)	(2)
Log number of firms financed in the same quarter	0.066**	0.171***
	(0.033)	(0.062)
Control variables	Yes	Yes
Exit-year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Number of observations	1,779	1,779
R-squared	0.36	0.36
Coefficient on Instrument and First Stage Statistics		
Log dollars raised by buyout funds 5-8 quarters before firm funded		0.624***
		(0.099)
Partial R-squared		0.324
F-statistic		50.63

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Median Valuation of Successful Firms

	Pre-money value conditional on IPO	Pre-money value on all exits above $ 50 million
	(1)	(2)
Log number of firms financed in the same quarter	0.184*** (0.054)	0.063* (0.034)
Firm's age at IPO	-0.016** (0.007)	-0.007 (0.004)
Log total funds raised prior to exit	0.403*** (0.028)	0.335*** (0.019)
Log value of NASDAQ on day of exit	0.880* (0.476)	1.026*** (0.307)
Startup based in California	0.118** (0.050)	0.026 (0.038)
Startup based in Massachusetts	0.079 (0.074)	-0.064 (0.055)
Exit year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Number of observations	1,197	1,779

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