Department of Management

Birkbeck UNIVERSITY OF LONDON

The Impact of Innovation on Venture Capital Investment

IP Seminar
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Introduction

- Background:
  - Global Insight (2007) estimated total revenue from 24,000 U.S. VC-backed firms to be $2.3 trillion (18% of GDP), and total employment to be 10.4 million (eg. Apple, Microsoft, Intel, Amazon ..)
  - Tighter protection of IPRs reduces expropriation risks and encourages VCs to invest in technology firms
  - Early stage technology investors give much weight to investment selection criteria related to innovation e.g. protection of intellectual property, platform and uniqueness (Clarysse, 2004)
  - VC investors receive little on their investment until a liquidation event occurs: IPO or M&A exits define VC performance – represent 85%-95% of all exits depending on investment stage (Giot, 2007)
- Objective:
  - To examine the influence of patented innovation on VC investment performance

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RBV Theory

- Patents are *critical resources* of the new firm
  - Penrose(1959) – firm returns associated with resources held
  - Barney(1991) – critical resources characterised by *value, rareness, imitability, substitutability* and not mobile across firms
  - Grant&Spender(1996) – KBV and intangible/codified knowledge resources critical for technology-based firms (TBFs)
- Help reduce risks associated with *information asymmetry* (Amit, 1998)
- Act as an insurance policy by enabling VCs to recover some residual value in the event of business failure
- Crucially, result in sustainable *competitive advantage* (Porter, 1979,1985) and *superior performance* (Griliches, 1981; Romer, 1986, 1990; Granstrand, 1999) for the firm

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Choice of Exit Route

- Many factors can influence the choice of exit routes
  - The literature refers to financial, information, timing and market conditions
  - Exit choices follow a performance hierarchy: top-performing firms choosing IPOs, firms opting for trade sales performing less well
  - Troubled firms result in delayed exits or write-offs
- Comparing the performance of exit routes
  - IPO mean return: 404%-465% (Hege, 2006; Cumming, 2003)
  - M&A mean return: 143%-156% (Hege, 2006;Cumming, 2003)
  - IPOs ave. value multiple 16x; M&As ave. value multiple 7x (Das, 2003; Metrick, 2007)

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Empirical Studies of Patents and VC Exits

- Few empirical studies exist and they tend to be sector-specific
- Larger patent stocks increase likelihood of IPO exit in the semiconductor industry (Hsu and Ziedonis, 2007)
- Positive correlations between patenting and firm's performance including total VC investment and exit status in the software sector (Mann and Sager, 2007)

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Research Hypotheses

based on RBV

1. *Exit choice is associated with TBF innovation*
2. *Total VC investment is associated with TBF innovation*
3. *Exit value is associated with TBF innovation*
4. *Exit multiple is associated with TBF innovation*

TBF= Technology-based firm

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Method and Data

- Sample of 1504 VC-backed exits in 7 technology sectors over 2 decades i.e. 1980-2000 (> 50% of population)
  - 961 IPOs
  - 543 M&As
  - 4261 patents filed (and granted) prior to IPO
- Venture data sources
  - Thomson VentureXpert database
  - Timing: firm formation and IPO dates
  - Venture capital investment i.e. number of VC investors and total venture capital invested prior to IPO
  - Venture capital performance i.e. firm value at IPO (IPO value), investment multiple (IPO value/total VC invested)
- Patent data sources
  - NBER/USPTO and Delphion databases
  - Number of patents, filing/grant dates, patent citations, etc
- Multilevel regression models are estimated

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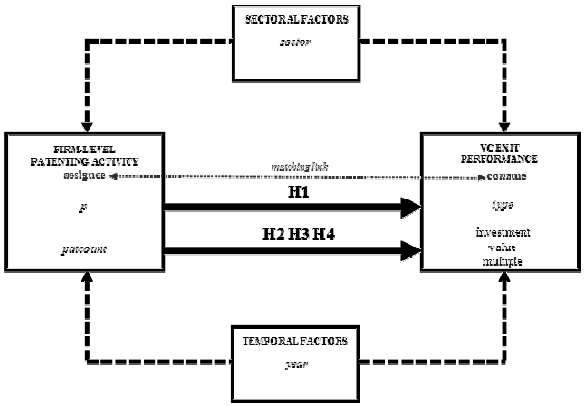
Model Variables



Note: Continuous variables are shown in italics.

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Sectoral Distribution

VC Exits and Patents Filed

Technology sector	M&A exits	Patent filed	IPO exits	Patent filed	Total exits	Total patents filed
Biotechnology	38	110	117	600	155	710
Communications	102	123	122	293	224	416
Computer hardware	63	133	93	305	156	438
Computer software	176	98	192	136	368	234
Internet specific	42	3	124	99	166	102
Medical/health	79	268	186	806	265	1074
Semiconductor/electronics	43	409	127	878	170	1287
Total	543	1144	961	3117	1504	4261

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Temporal Distribution

VC Exits and Patents Filed

Exit year	M&A exits	Patent filed	IPO exits	Patent filed	Total exits	Total patents filed
1980	0	0	14	30	14	30
1981	0	0	16	23	16	23
1982	0	0	13	29	13	29
1983	0	0	45	103	45	103
1984	0	0	17	19	17	19
1985	2	156	13	3	15	159
1986	0	0	36	97	36	97
1987	3	3	28	59	31	62
1988	1	0	15	42	16	42
1989	3	10	23	72	26	82
1990	4	1	24	75	28	76
1991	2	4	58	163	60	167
1992	36	102	57	129	93	231
1993	33	78	69	369	102	447
1994	46	105	52	98	98	203
1995	50	61	76	404	126	465
1996	57	105	129	637	186	742
1997	84	150	66	315	150	465
1998	99	192	49	129	148	321
1999	123	177	161	321	284	498
Total	543	1144	961	3117	1504	4261

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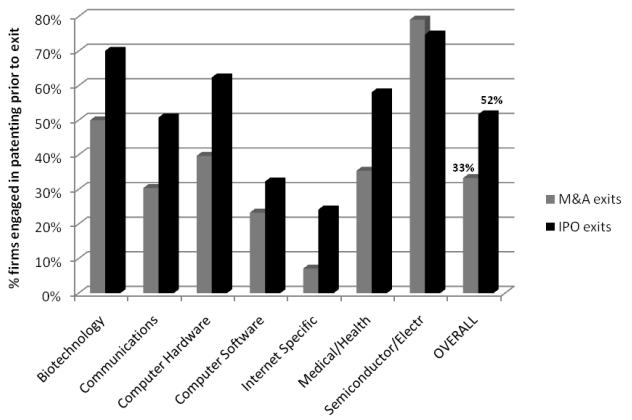
Sectoral Patenting Rate

(1980-2000)



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Difference in Patenting Rates by VC Exit Routes

	M&A exits			IPO exits			Diff. means
	Number of observations	Mean	Standard deviation	Number of observations	Mean	Standard deviation	*p*-Value Pr(IPO > M&A)
Biotechnology	38	0.50	0.51	117	0.71	0.46	0.017
Communications	102	0.31	0.46	122	0.51	0.50	0.000
Computer hardware	63	0.40	0.49	93	0.62	0.49	0.003
Computer software	176	0.23	0.42	192	0.32	0.47	0.027
Internet specific	42	0.07	0.26	124	0.24	0.43	0.001
Medical/health	79	0.35	0.48	186	0.58	0.49	0.000
Semiconductor/ electronics	43	0.79	0.41	127	0.75	0.44	0.282
Total	543	0.33	0.47	961	0.52	0.50	0.000

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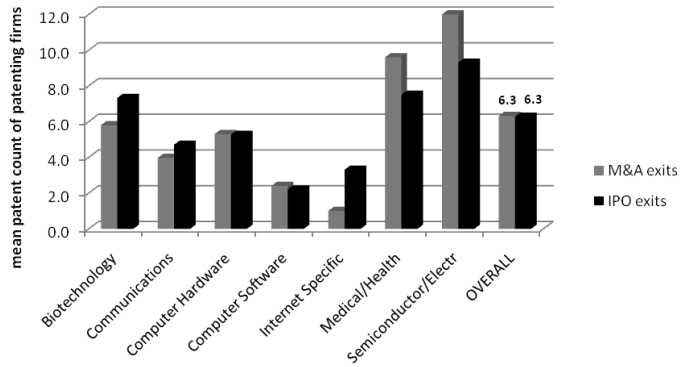
Sectoral Patent Count
(1980-2000)



Difference in Patent Count by VC Exit Routes
(patenting firms)

	M&A exits			IPO exits			Diff. means
	Number of observations	Mean	Standard deviation	Number of observations	Mean	Standard deviation	*p*-Value Pr(IPO > M&A)
Biotechnology	19	5.79	5.02	82	7.32	10.23	0.264
Communications	31	3.97	4.55	62	4.73	11.00	0.357
Computer hardware	25	5.32	9.94	58	5.26	9.52	0.511
Computer software	41	2.39	2.42	62	2.19	3.02	0.636
Internet specific	3	1.00	0.00	30	3.30	3.61	0.143
Medical/health	28	9.57	9.53	108	7.46	9.49	0.852
Semiconductor/ electronics	34	12.03	23.43	95	9.24	10.85	0.820
Total	181	6.32	12.1	497	6.27	9.56	0.522

Multilevel Linear Regression Model

$$y_{ij} = \beta_0 + \beta_1 patenting_{ij} + \beta_2 patcount_{ij} + \beta_3 year_{ij} + \beta_4 type_{ij} + u_i + e_{ij}$$

i level-two units

j level-one nested observations

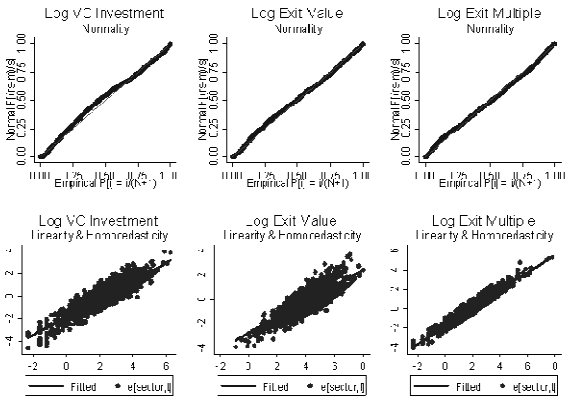
- The i.i.d. (independent and identically distributed) errors assumption is unlikely for panel data where the observations consist of the same units measured repeatedly
- A more plausible panel-data model included two error terms
  - One is common to each of the *i* units, but differs between units (u_i)
  - The second is unique to each of the *i, j* observations (e_{ij})
- Units are defined as sectors and sectoral panels are treated with total VC investment, exit value and exit multiple as dependent variable y_{ij}
- Patenting and patent count as independent variables $patenting_{ij}$ *and* $patcount_{ij}$ together with the two variables $year_{ij}$ *to* $type_{ij}$ to control for exit year and exit route, respectively

Results

Sectoral Data Panels	Multilevel Fixed-Effects Regression		
	Log VC Investment	Log exit value	Log exit multiple
R^2 within	0.1535	0.2661	0.0613
R^2 between	0.7280	0.6308	0.0829
R^2 overall	0.1818	0.2917	0.0544
Mean VIF	1.15	1.15	1.15
Prob > F	0.0005***	0.0000***	0.0002***
Patenting *(β_1 coefficient, VIF = 1.25)*	0.1492*	—	−0.1575*
Patent count *(β_2 coefficient, VIF = 1.22)*	0.0168*	0.0133***	—
Exit year *(β_3 coefficient, VIF = 1.13)*	0.1094***	0.0977***	—
Exit type *(β_4 coefficient, VIF = 1.15)*	0.6758***	1.3455***	0.6567***
σ_u *(fixed effects)*	0.2462	0.3666	0.2584
σ_e *(standard errors)*	1.2102	1.0683	1.3000
ρ *(intraclass correlation[a])*	0.0397	0.1053	0.0380

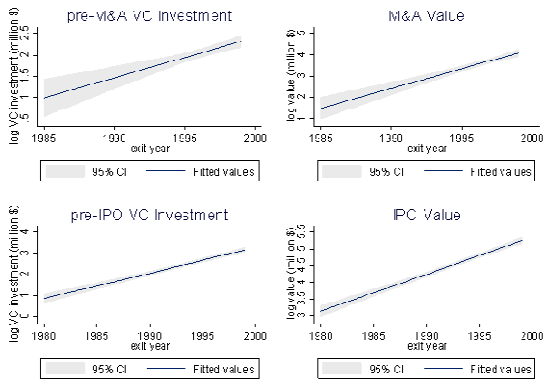
***1% significance level, **5% significance level, *10% significance level.
[a]ICC is the fraction of variance due to sectoral fixed effects (u_i).

Multilevel Linear Regression Assumptions



Fitted VC Investment and Exit Value

by Exit Route



Discussion and Conclusion

- TBFs exiting via an IPO are associated with higher patenting rates (52%) than those exiting via an M&A (33%)
- Mean total VC investment, exit value and exit multiple for firms which exited via an IPO were higher by 84%, 115% and 111% respectively, than for technology firms exiting via an M&A
- The paper expands the venture capital literature by showing that technology firms across multiple sectors, characterized by higher innovation, are associated with <u>larger VC investment</u> and <u>superior exit value,</u> irrespective of exit route, but <u>not</u> with higher exit multiples
- Whilst average VC investment and exit value have increased steadily over time, exit multiples have been relatively stable
- VC firms consider patented innovations as important and significant quality signals which can help with investment activities and contribute to value creation

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