Exploring the Patent Explosion

Bronwyn H. Hall

UC Berkeley and NBER

Setting the scene

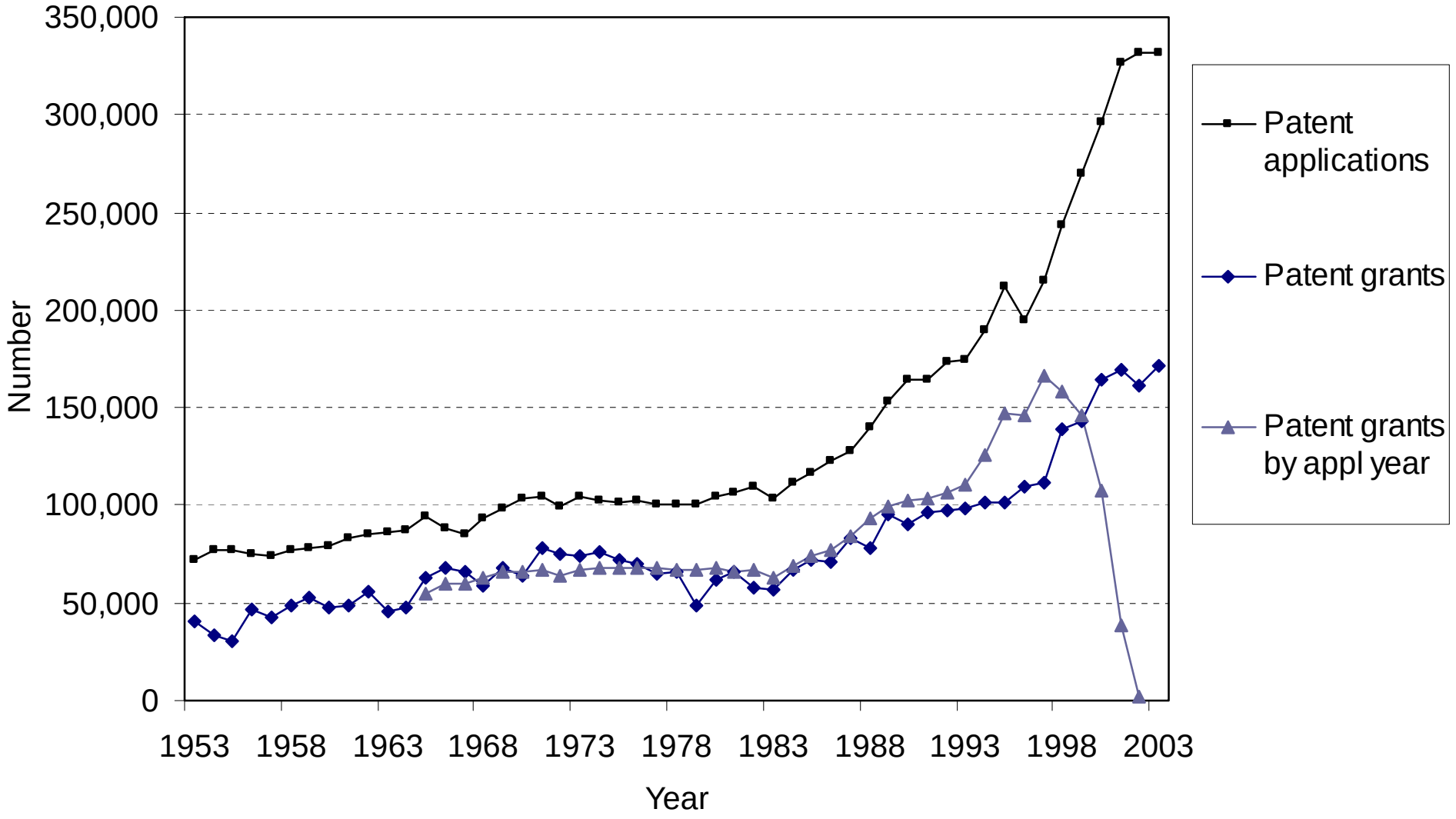
- Surge in worldwide patenting, especially in U.S.
  - Increased firm focus on IP management and strategy
- => Renewed interest in an old question:

  "Do patents encourage innovation?"
  - Survey evidence -- patents not very effective for appropriating returns to innovation in many industries
  - But ...
    - may have value for startup firms in high technology or knowledge intensive industries
    - may be useful for knowledge trading

The patent explosion

- Aggregate USPTO applications and grants for utility patents 1953-2003
  - Sharp break in trend in 1983/84
    - Applications and grants were roughly flat, then begin to grow at about 5-6% per year
    - Real R&D increases only 2.4% per year over same period

Figure 1
USPTO Utility Patents 1953-2003



Tests for structural break

- US series has a unit root in both levels and logarithms
  - $\Rightarrow$ use growth rates to look for break
- Andrews (1993) test for a single unknown structural break
  - 23.0 with p-value < .001; break at 1984
- T-test for change in growth rate between 1983 and 1984
  - 6.9% (1.4%) with p-value = .000

What changed?

- 1982 creation of CAFC/court
  - Patent validity more likely to be upheld
- 1985/6 TI strategy
  - sues several Japanese semiconductor firms and wins
- 1986 Kodak-Polaroid decision on instant cameras
  - $1B judgment; injunction shut down Kodak
- Result:
  - patents more likely to be upheld in litigation
  - consequences more negative for alleged infringers,

especially in complex product industries like computing and electrical equipment

Patent system viewed by a "two-handed" economist

Effects on	Positive	Negative
Innovation	creates an incentive for R&D	impedes the combination of new ideas & inventions; can raise transaction costs; inhibits cumulative invention
Competition	facilitates entry of new or small firms with limited assets	creates short-term monopolies, which may become long-term in network industries

Patents and competition (+)

- Increase dynamic competition by facilitating entry
  - Necessary for securing financing in knowledge-intensive industries (where there are few tangible assets)
- Can lead to competition-enhancing vertical disintegration by facilitating trade in technology
  - Chemicals - Arora, Fosfuri, Gambardella
  - Semiconductor design firms – Hall & Ziedonis

Patents and innovation (-)

- The patent thicket
  - Heller and Eisenberg – problem of contracting when many inputs are essential
    - High transaction costs
    - Scotchmer – negotiations can breakdown with complementary inputs, due to holdup
  - Large numbers of patents in a given area, impossibility of adequate search
    - Ex post holdup by patentholder after costs are sunk (many examples)

Argument of this paper

Nontraditional uses of patents more important in complex product industries than in discrete product industries:

- "key difference between a complex and a discrete technology is whether a new, commercializable product or process is comprised of numerous, separately patentable elements versus few" (Cohen, Nelson, and Walsh 2001)
- Discrete - firms tend to use patents to block the development of substitutes by rivals
- Complex - firms more likely to use patents to induce rivals to negotiate for property rights over complementary technologies.

Patenting in Complex Technologies

- Surveys: Levin et al 1984; Cohen et al 1998
  - Patents not as important as other means for appropriating returns to R&D except in some chemicals/metal products industries
  - complex product industries – used for cross-licensing, to prevent blocking
- Hall and Ziedonis 2001:
  - Patents used for defensive purposes in semiconductors, to defend against suits and for cross licensing
  - Also important for securing financing for startups

Industry classification

Discrete Product

- Paper
- Chemicals
- Pharmaceuticals & soap
- Oil

- Food & tobacco
- Textiles & apparel
- Lumber & wood
- Furniture
- Printing
- Rubber & plastics
- Stone, clay, and glass
- Primary and fabricated metals

Complex Product

- Machinery & engines
- Computing equipment
- Electrical machinery
- Instruments (incl. medical)
- Communication equipment

- Transportation eq.
- Autos & auto parts
- Misc n.e.c.

Robert Barr, Cisco, 2002

My observation is that patents have not been a positive force in stimulating innovation at Cisco. Competition has been the motivator; bringing new products to market in a timely manner is critical. Everything we have done to create new products would have been done even if we could not obtain patents on the innovations and inventions contained in these products. .....

The only practical response to this problem of unintentional and sometimes unavoidable patent infringement is to file hundreds of patents each year ourselves, so that we can have something to bring to the table in cross-licensing negotiations. .....

The time and money we spend on patent filings, prosecution, and maintenance, litigation and licensing could be better spent on product development and research leading to more innovation. But we are filing hundreds of patents each year for reasons unrelated to promoting or protecting innovation.

Empirical investigations

- What accounts for the surge in patenting?
  - By region of the world
  - By technology (chemical/electrical/mechanical)
  - By industry (discrete/complex)
- Can we see evidence that patents help entry?
  - Preliminary results
  - Compare incumbents and new entrants
  - Compare discrete and complex technology industries

Data for further analysis

- All U.S. utility patents granted between 1963 and 2002 (3.4M)
  - Application lags => only complete through about 1997
- Subset applied for between 1974 and 1994
  - All patents 1.67M
  - Granted to US inventors 938K (56%)
  - Granted to US corporations 676K (40%)
  - Granted to US manufacturing corporations matched to Compustat 312K (20%)

Accounting for patent growth

Define

g_t = growth of patenting from time *t-1* to *t*

g_{it} = growth of patenting in class or region *i* from time *t-1* to *t*

s_{it-1} = share of patents in class or region *i* at time *t-1*

Then

$$g_t = \sum_{i=1}^{n} s_{i,t-1} g_{it}$$

Plots show $s_{it-1}\, g_{it}$ for different *t* and *i*

Figure 3
Accounting for U.S. Patent Application Growth by Region of Inventor

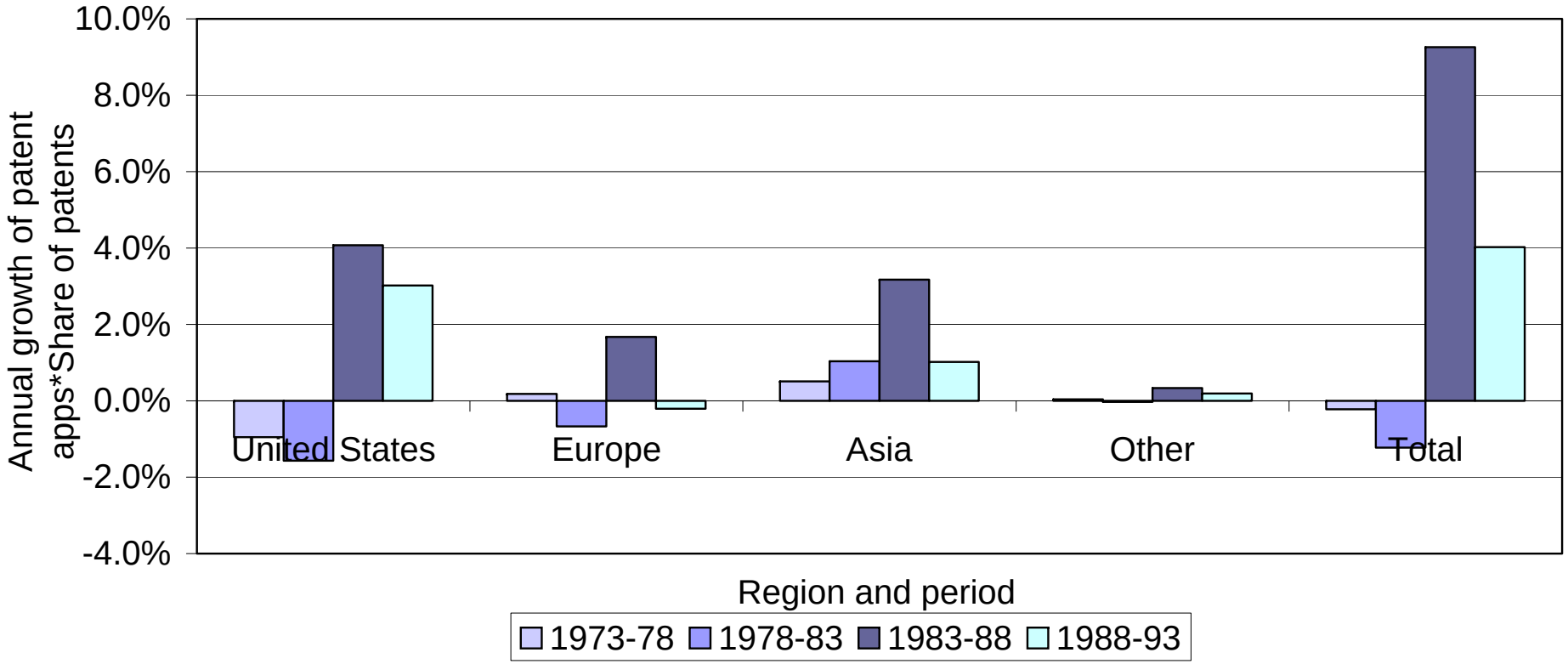


Figure 4a
Accounting for Patent Application Growth
Broad Technology Class

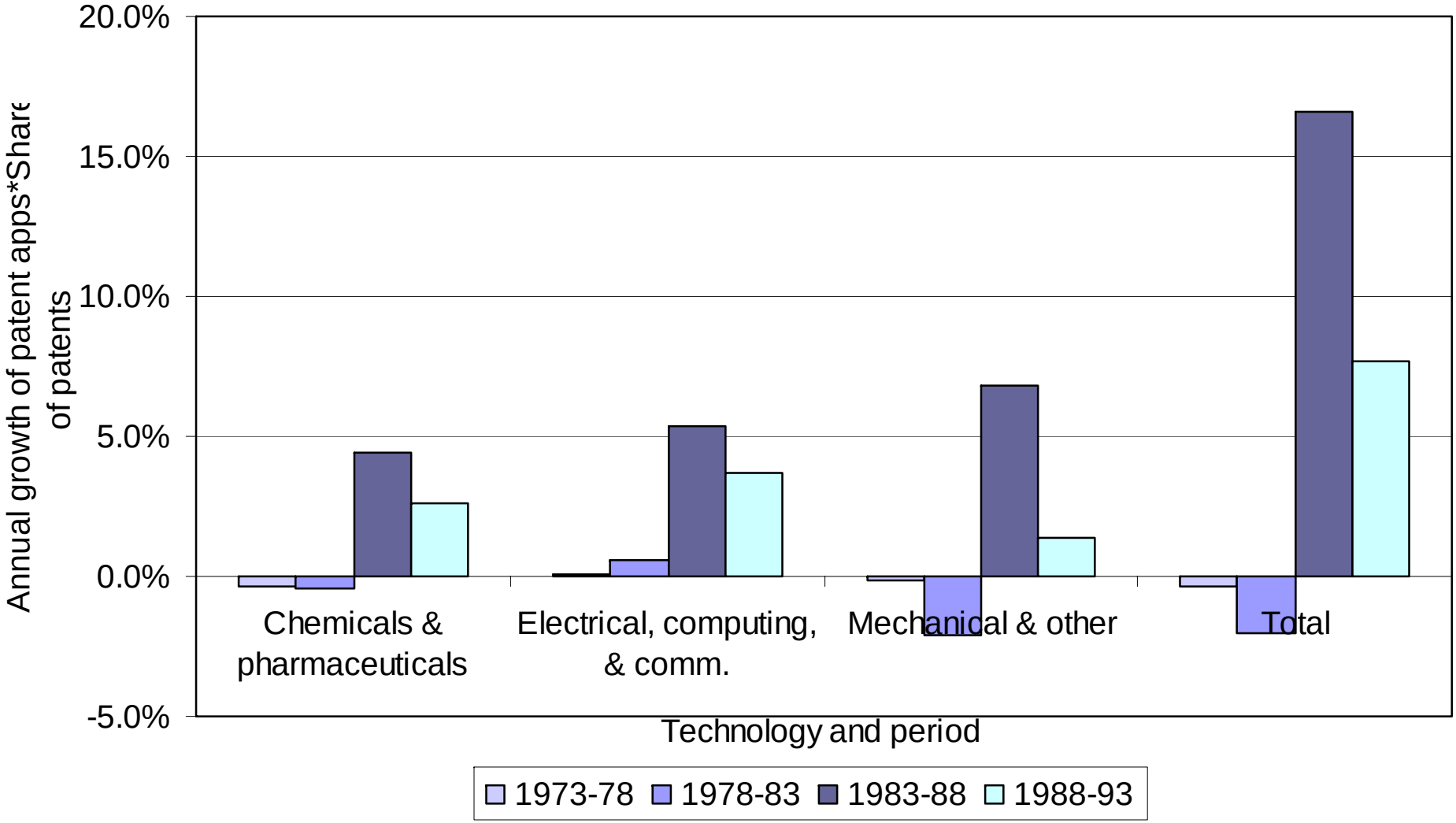


Figure 4
Accounting for U.S. Inventor Patent Application Growth
Broad Technology Class

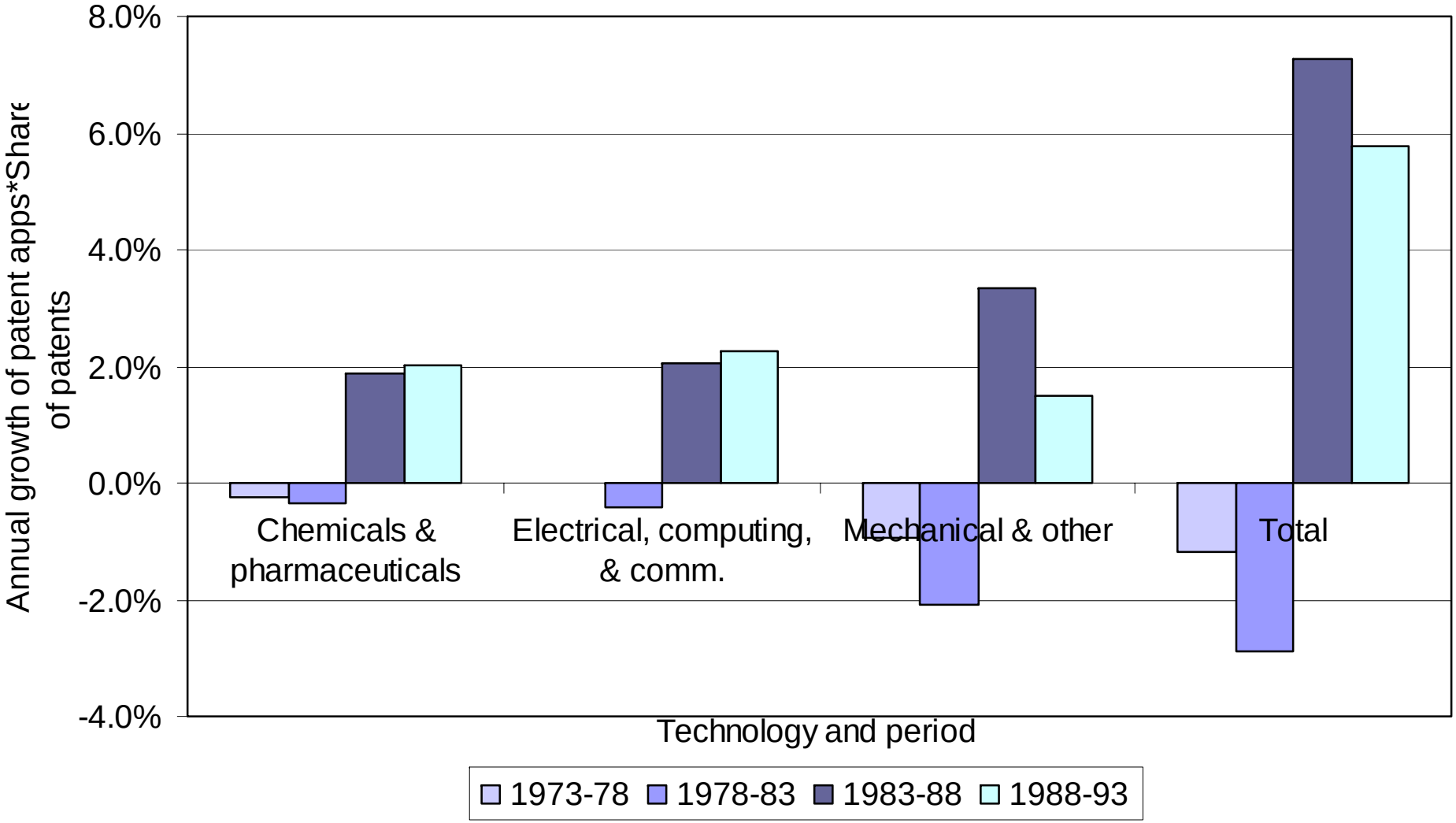


Figure 5
Accounting for Compustat Firms Patent Application Growth
Broad Industry Class

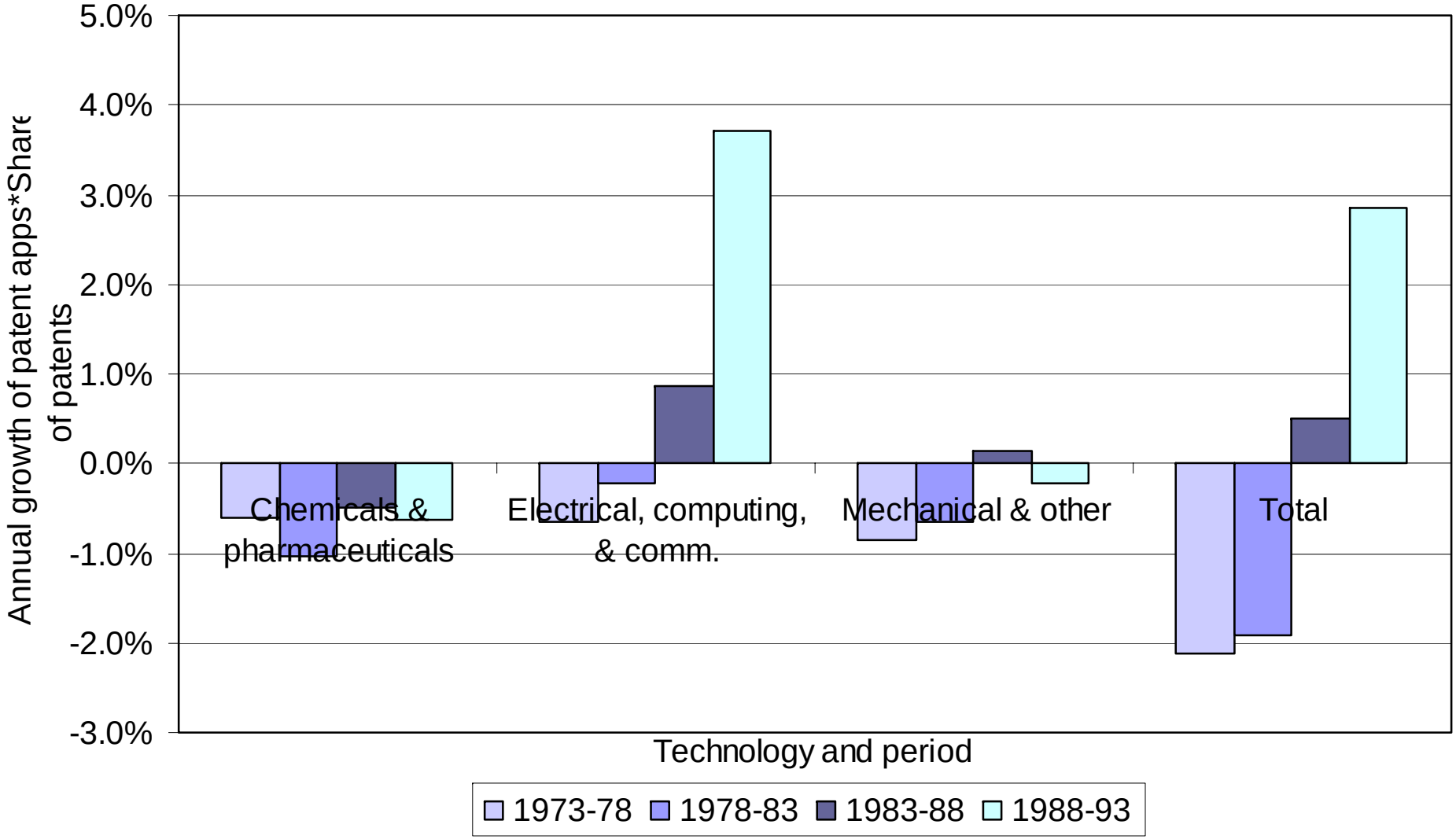
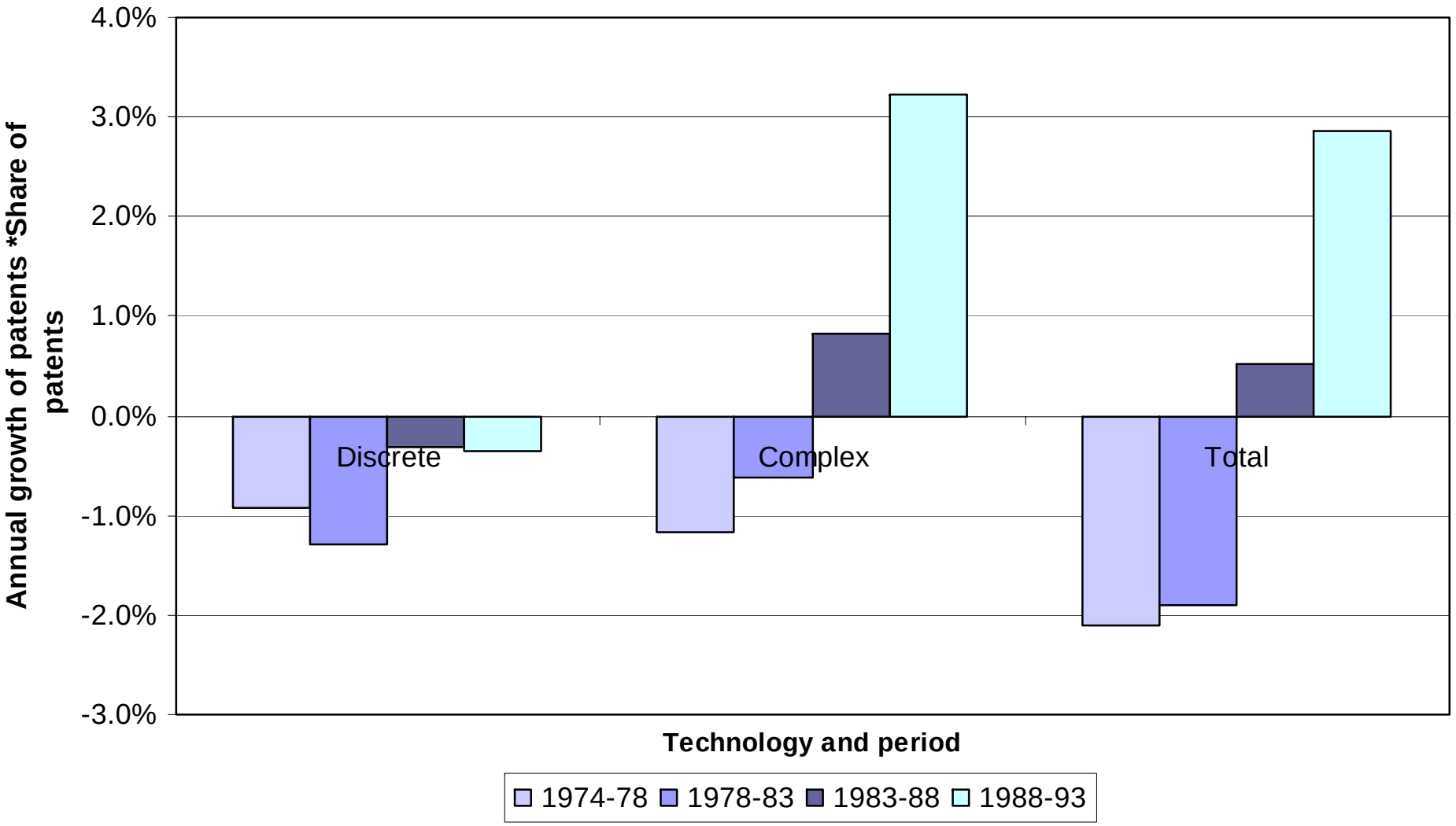
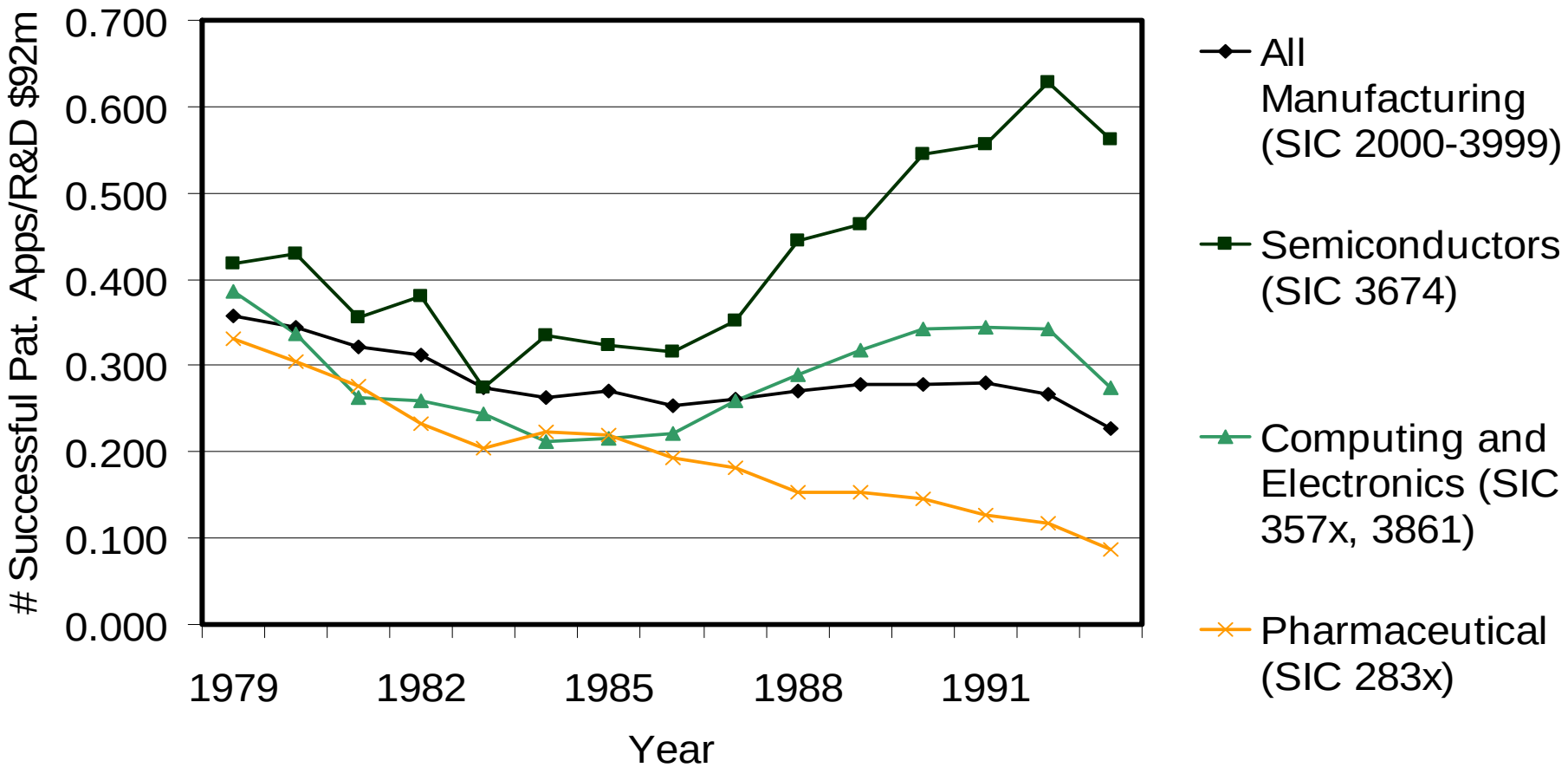


Figure 5p
Accounting for Compustat Firms Patent Growth
Discrete vs Complex Product Industries



Patent propensity 1979-93



Summary

- Growth largely from US inventors; some from Asia in 1983-88 period
- Growth post-1983 in all technologies; more in computing/electrical 1988-93
- Looking at publicly-traded US manufacturing, growth ONLY in computing/electrical equipment firms.

Implications for patent value

- Discrete product industries
  - Not much change in the use of patents
  - Valuable, at least in pharmaceuticals
- Complex product industries
  - Patents may not add to firm value of incumbents, above and beyond their R&D assets
  - Patents held by new entrants may add value, especially post-1984
    - Help to secure more equity financing, at a lower price
- Use data on US firms 1980-1989 to “test” these hypotheses

Data sample

- ~1400 U.S. manufacturing firms 1980-89
  - At least one patent
  - At least five years of data
  - An entrant is a firm that is listed on one of the US stock exchanges for the first time

Type	Number of firms	Number of observations
Incumbents	948	8524
Entrants 1980-84	224	653
Entrants 1985-89	177	540
Total	1349	9717

Basic market value model

$Q = V/A$

$V =$ market value of firm

$A =$ book value of tangible assets

$K =$ stock of R&D assets

$P =$ stock of patents

$$Log(Q_{it}) = \delta_t + \beta_K \left(\frac{K_{it}}{A_{it}} \right) + \beta_P \left(\frac{P_{it}}{K_{it}} \right) + \varepsilon_{it}$$

Estimation strategy

- All estimates include a full set of time dummies
- Slopes and time dummies allowed to vary across
  - Incumbent/entrant
  - Time periods (1980-84; 1985-89)
  - Discrete/complex technologies
- Robust standard errors reported

Market Value Regression

	1980-1984				1985-1989			
	Incumbents 1979		**Entrants 1980-84**		**Incumbents 1984**		**Entrants 1985-89**	
Variable	Coeff.	s.e.	Coeff.	s.e.	Coeff.	s.e.	Coeff.	s.e.
R&D stock/ assets	0.750	.067	0.531	.085	0.300	.033	0.447	.048
Pat stock/ R&D stock	-.026	.011	-.022	.036	0.009	.009	0.059	.031
D(entrant) in first year			.922	.156			.481	.117
Firms	948		224		959		176	
Observations	4385		652		4139		537	

Comparing Incumbents and Entrants

Coefficient of Patent stock/R&D stock

Industry	All	Discrete	Complex	Difference between discrete and complex
		1980-84		
Incumbents	-.026 (.011)	-.025 (.014)	-.027 (.023)	.002 (.027)
Entrants	-.022 (.036)	-.068 (.055)	-.010 (.038)	.058 (.067)
Difference	.004 (.038)	-.043 (.057)	.037 (.052)	.080 (.077)
		1985-89		
Incumbents	.009 (.009)	-.014 (.025)	.014 (.010)	.000 (.027)
Entrants	.059 (.031)	.023 (.015)	.272 (.062)	.249 (.069)
Difference	.050 (.033)	.037 (.030)	.258 (.063)	.221 (.070)
8589-8084		.080 (.064)	.220 (.098)	

Significant at the 5% level

Conclusions

- Patenting has increased in complex product industries
  - Mostly in the US, but with Asia and Europe following
  - controlling for R&D
  - mostly for defensive purposes and cross-licensing negotiations
- Patents have become more valuable for entrants in complex product industries, but not in discrete product industries
  - In electrical and computing industries, median R&D/assets ratio for entrants is above one half, so ownership of knowledge assets important for securing returns

Further preliminary work

- Entrants do not have more patents (adjusting for their R&D)
- Entrants' patents are more highly cited (suggesting that valuation effect is due to higher patent value)
- Software patenting – new project with Megan Macgarvie (BU)
  - SW pats worth more; citations worth less
  - Strengthens post-1994