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
Tests for structural break

- US series has a unit root in both levels and logarithms
  - ⇒ 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

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

확서: 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

확서: 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.
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

\[ g_t = \text{growth of patenting from time } t-1 \text{ to } t \]
\[ g_{it} = \text{growth of patenting in class or region } i \text{ from time } t-1 \text{ to } t \]
\[ s_{it-1} = \text{share of patents in class or region } i \text{ at time } t-1 \]

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

United States
Europe
Asia
Other
Total

Region and period
1973-78
1978-83
1983-88
1988-93

Annual growth of patent apps*Share of patents

-4.0%
-2.0%
0.0%
2.0%
4.0%
6.0%
8.0%
10.0%
Figure 4a
Accounting for Patent Application Growth
Broad Technology Class

Annual growth of patent apps*Share of patents

Technology and period

Total

Chemicals & pharmaceuticals

Electrical, computing, & comm.

Mechanical & other

1973-78
1978-83
1983-88
1988-93

-5.0%
0.0%
5.0%
10.0%
15.0%
20.0%
Figure 4
Accounting for U.S. Inventor Patent Application Growth
Broad Technology Class

Annual growth of patent apps*Share of patents

Chemicals & pharmaceuticals
Electrical, computing, & comm.
Mechanical & other
Total

Technology and period


November 2004 Stanford seminar
Figure 5
Accounting for Compustat Firms Patent Application Growth
Broad Industry Class

Chemicals & pharmaceuticals
Electrical, computing, & comm.
Mechanical & other
Total

Annual growth of patent apps*Share of patents

Technology and period

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

Technology and period


Annual growth of patents * Share of patents

-3.0% -2.0% -1.0% 0.0% 1.0% 2.0% 3.0% 4.0%
Patent propensity 1979-93

- All Manufacturing (SIC 2000-3999)
- Semiconductors (SIC 3674)
- Computing and Electronics (SIC 357x, 3861)
- Pharmaceutical (SIC 283x)
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

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of firms</th>
<th>Number of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incumbents</td>
<td>948</td>
<td>8524</td>
</tr>
<tr>
<td>Entrants 1980-84</td>
<td>224</td>
<td>653</td>
</tr>
<tr>
<td>Entrants 1985-89</td>
<td>177</td>
<td>540</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1349</strong></td>
<td><strong>9717</strong></td>
</tr>
</tbody>
</table>
Basic market value model

\[ Q = \frac{V}{A} \]

\[ V = \text{market value of firm} \]

\[ A = \text{book value of tangible assets} \]

\[ K = \text{stock of R&D assets} \]

\[ P = \text{stock of patents} \]

\[ \log(Q_{it}) = \delta_t + \beta_K \left( \frac{K_{it}}{A_{it}} \right) + \beta_P \left( \frac{P_{it}}{K_{it}} \right) + \varepsilon_{it} \]
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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Incumbents 1979</th>
<th>Entrants 1980-84</th>
<th>Incumbents 1984</th>
<th>Entrants 1985-89</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff.</td>
<td>s.e.</td>
<td>Coeff.</td>
<td>s.e.</td>
</tr>
<tr>
<td>R&amp;D stock/assets</td>
<td>0.750</td>
<td>0.067</td>
<td>0.531</td>
<td>0.085</td>
</tr>
<tr>
<td>Pat stock/R&amp;D stock</td>
<td>-0.026</td>
<td>0.011</td>
<td>-0.022</td>
<td>0.036</td>
</tr>
<tr>
<td>D(entrant) in first year</td>
<td>.</td>
<td>.</td>
<td>.922</td>
<td>.156</td>
</tr>
<tr>
<td>Firms</td>
<td>948</td>
<td>224</td>
<td>959</td>
<td>176</td>
</tr>
<tr>
<td>Observations</td>
<td>4385</td>
<td>652</td>
<td>4139</td>
<td>537</td>
</tr>
</tbody>
</table>
Comparing Incumbents and Entrants

Coefficient of Patent stock/R&D stock

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

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