The Surge in Patenting by U.S. Semiconductor Firms: An Empirical Analysis

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Motivation

• Overall increase in US patenting since early 1980s
  • Kortum and Lerner (1998)
    – “friendly court” hypothesis
    – “regulatory capture” hypothesis
    – “fertile technology” hypothesis
    – “managerial improvements” hypothesis

• Patents still ineffectual for firms in most industries?
  • Yale Survey 1982
  • Carnegie Mellon Survey (CMS) 1994

• Why, then, do firms patent?
Why Semiconductors?

• Among the industries *least* reliant on patents to appropriate returns to R&D (Yale, CMS)
  • Pivotal role of lead time, secrecy and complementary manufacturing capabilities

• Yet witness a dramatic surge in patenting by semiconductor firms during past decade.
Patent Propensity:
US Semiconductor Firms (SIC 3674), 1979-94
Patent Propensity:
Semiconductors vs. All US Manufacturing, 1979-94

# Successful Pat. Apps/R&D $92m

Year


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

I. Examine actual changes in firm-level patenting behavior within one broad technological area over time.
   – sample of firms in US semiconductor industry (sic3674)
     • Pro: able to identify R&D expenditures primarily directed toward semiconductor-related technologies
     • excludes “systems” firms and non-US firms (AT&T or IBM; Hitachi)

II. Investigate differences among types of firms
   – manufacturers with large patent portfolios before US patent rights were strengthened, or “pre-CAFC” (TI)
   – manufacturers that exhibit a dramatic rise in patent propensity post-CAFC (LSI Logic, National Semiconductor)
   – firms entering the industry during the “pro-patent” era
     • specialized design firms (Xilinx, S3)

III. Gain insights from interviews
Empirical Analysis

• Is the surge in patenting driven by:
  – TI alone? (regulatory capture)
  – capital-intensive manufacturers? (strategic response)
    • Increased cost and risks associated with infringement
      – Increased demands for royalties
      – Uncertainty regarding owners of technological inputs
      – Escalating costs, rapid depreciation of fabs
      • Costs of halting production
      • Time and costs associated with “designing around”
    • Increased value of patents as “legal bargaining assets”
  – Or…a simple change in the mix of firms over time?
    • Emergence of design firms
Empirical Analysis: Data

- 110 US semiconductor firms (SIC 3674)
- Compiled entity-level patent portfolios
- Matched with Compustat data
- Produced sample of 97 firms in unbalanced panel, 1980-94.
Basic Specification

\[ Y = \text{number of successful patent applications by firm } i \text{ in year } t \]

Regressors:
- Firm Size (log of employment)
- R&D Intensity (log; deflated)
- Capital Intensity (log; deflated)
- \( D=1 \) if firm entered after 1982
- \( D=1 \) if firm is manufacturer (v. specialized design firm)
- \( D=1 \) if firm is Texas Instruments
- Time dummies, 1980-1994
Estimating the patent production function


\[ E[p_{it}|X_{it}] = \lambda_{it} = \exp(X_{it}\beta + \gamma_t) \]

MLE using “robust” standard errors

• Interpretation:
  • Coefficients measure elasticity of patenting w.r.t. X
    \[(1/\lambda_{it}) (d\lambda_{it}/dX_{it}\beta) = \beta\]
  • Year-to-year change in \(\gamma = \) approximate growth rate in patenting propensity controlling for X:
    \[\gamma_t - \gamma_{t-1} = \Delta \log \lambda_{it} - \Delta X_{it}\beta\]
    \[= \text{growth in expected patents less growth predicted by } \Delta X\]
Summary of Econometric Results

• Clear surge in patenting by US semiconductor firms since the early-to-mid 1980s.
Residual Growth in Patenting:
US Semiconductor Firms (Relative to 1980)
Summary of Econometric Results
(continued)

• Strong, positive “TI effect” (regulatory capture?)

• Surprisingly strong, positive role of capital investments on patenting decision (strategic response)
  – Patenting by manufacturers is 2-3x as responsive to changes in capital investments than to changes in R&D

• Design firms are roughly 37% more likely to patent, controlling for firm characteristics
  – Patenting decision depends heavily on size and R&D intensity (not capital investments)
Interviews

• Persons directly involved in patent strategy
  • TI
  • 3 capital-intensive manufacturers
  • 3 specialized design firms (2=post-1982 entrants)

• Main questions
  • Overview of IP and licensing practices
  • Evolution of patent strategy, 1975-98
  • Internal management changes (in R&D or patenting)
  • General views of US patent system
Summary of Interview Results

- **Capital-intensive manufacturers**
  - Strong demonstration effect of TI and Kodak-Polaroid cases
    - “Ramping up”; “harvesting latent inventions”
    - “If in doubt, patent”
  - Need to safeguard assets; avoid halt in production
    - “Exclude before you’re excluded”
  - Need to improve bargaining position with other patent owners
    - Control outflow of royalty payments
    - Secure royalty income
    - Gain access to external technology on more favorable terms
  - Changes (except TI) in management of patent process
    - “Patent advocacy committees”; increased bonuses; goals

- **Design firms**
  - Secure rights in niche product markets
  - Critical role of patents in attracting venture capital
  - One firm “opts out”
Conclusions

• Quantitative and qualitative evidence that “pro-patent” shift altered semiconductor firms’ incentives to obtain US patents

  – Not driven by direct “regulatory capture” effect alone
  – Witness “patent portfolio races” among large, capital-intensive firms.
  – Upsurge may reflect managerial change
    • Primarily in the management of the patenting and licensing process
Policy Implications

• Role of the patent system
  – Induce R&D investment
    • In semiconductors, alternative mechanisms more effective?
  – Provide socially beneficial disclosure of information
    • In semiconductors, product life cycles may outpace the issuance of related patents.
    • Consistent concerns that US patent standards are too low

• Stronger patent rights represent an implicit tax on innovation?

• Do stronger patent rights enable, or deter, entry?
  – Current evidence is mixed.