

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

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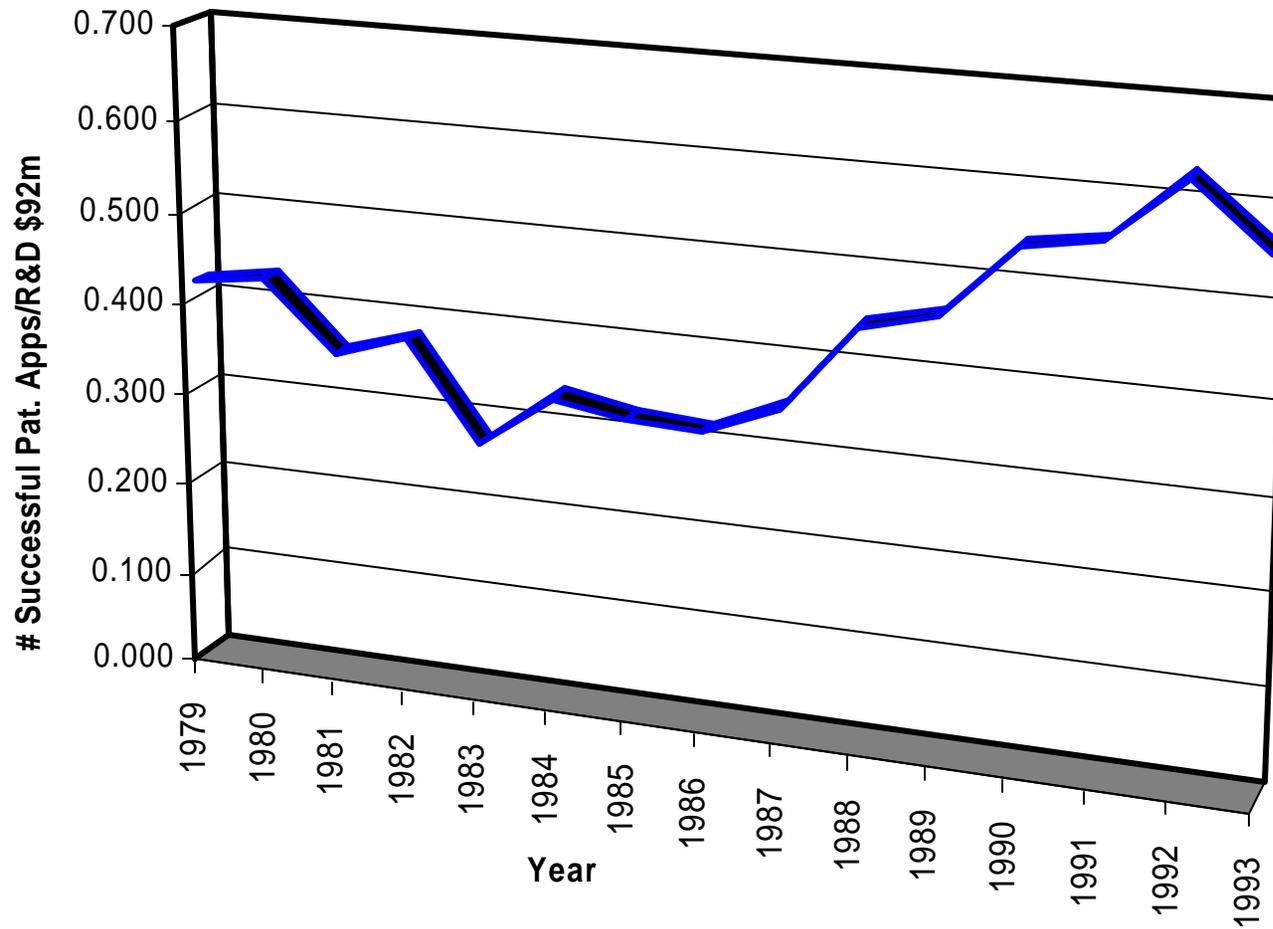
# Motivation

- 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?

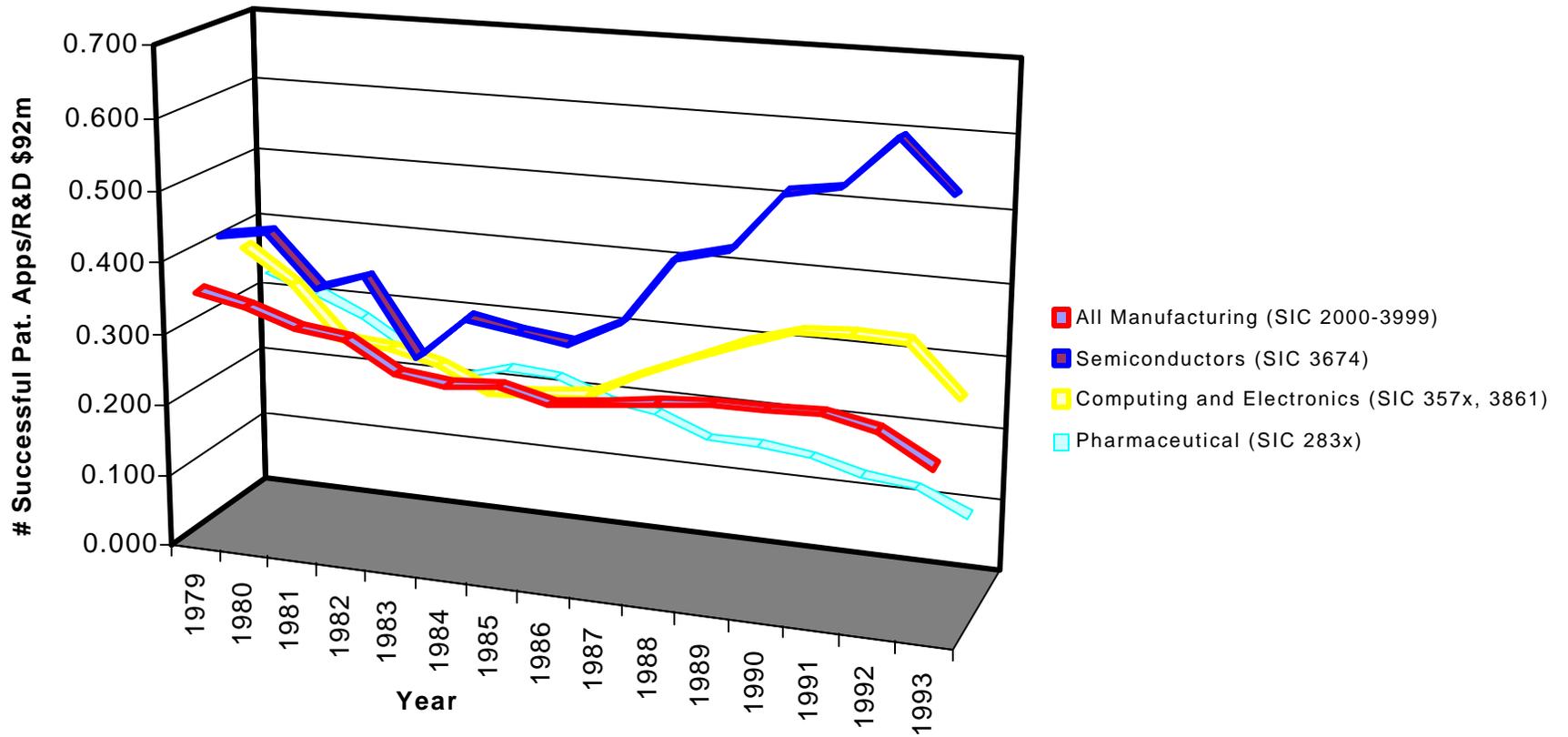
## Why Semiconductors?

- 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



# 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

$Y$  = number of successful patent applications by firm  $i$  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

- Poisson-based model (Pakes and Griliches 1980; HHG 1984).

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

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:

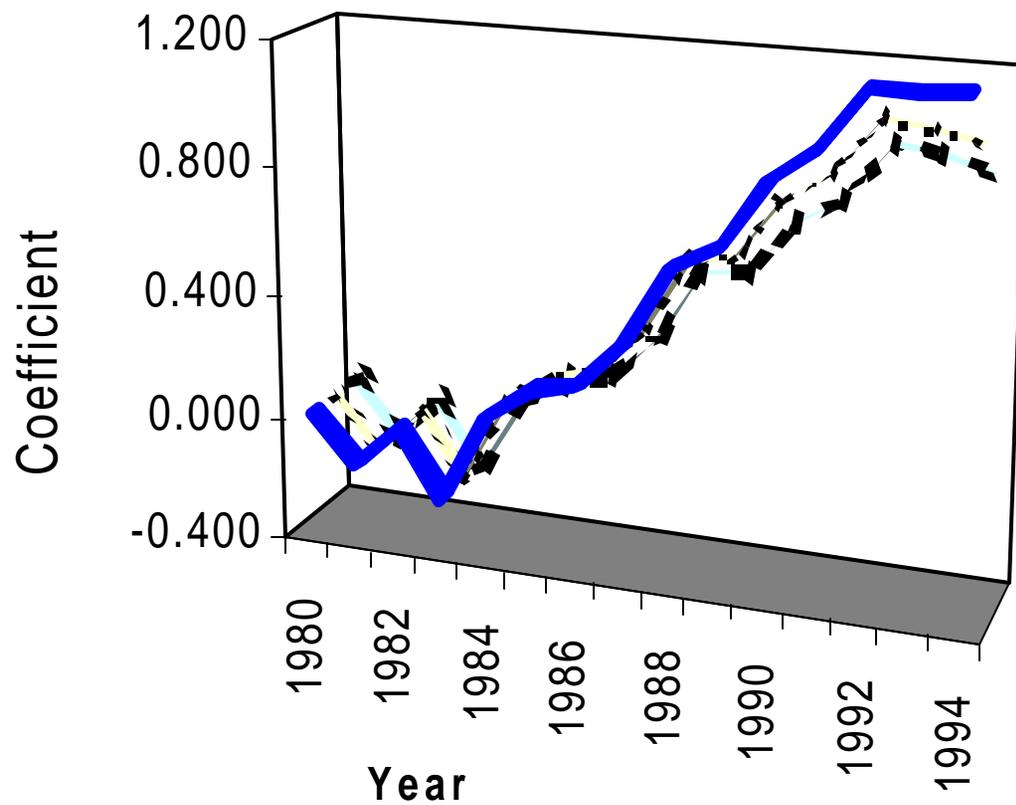
$$\gamma_t - \gamma_{t-1} = \Delta \log \lambda_{it} - \Delta X_{it}\beta$$

= 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.