Measuring the returns to innovation (2)

Prof. Bronwyn H. Hall
Globelics Academy
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Economic research on patents

- Normative – how should we design IP systems; how should a firm use them
- Positive – patents as a measure of inventive activity
  - knowledge value
  - knowledge flows

Patents as indicators

- A patent is a property right to a knowledge asset
- patents can be used to measure innovative output
  - Counts at the firm, industry, country level over time
  - Counts weighted by the number of subsequent citations that they receive
  - Citations from one patent to another – a map of the links between these “bits” of output or knowledge

- Requires understanding of patents:
  - how and why they are taken out, administered, and enforced
  - how this changes over time

Two types of data

- Patent information
  - Date of application and grant
  - Name and geographic location of inventor
  - Name and type of entity to which assigned
  - Detailed classification by technology
  - Title, abstract, description, and claims

- Citation information
  - Of other patents (in the same or different patent systems)
  - Of the scientific literature
  - Type of citation (examiner added, importance)

What are patent citations?

- Somewhat like citations in a research paper:
  - References to prior technology, either patents or other scientific literature on which the current patent builds or which it uses
  - Some added by the USPTO examiner (the “referee”)
  - Some added after the fact (not used by inventor)
  - Some added to avoid infringement (limit scope, defense against suits)
  - Some added for “teaching” (like survey articles)

- USPTO differs from EPO in citation practice

- Jaffe, Trajtenberg, Fogarty inventor survey (NBER)
  - About half correspond to some kind of knowledge flow
  - About one quarter to a very substantial flow
  - Remainder are primarily those added by others (not the inventor)
Some facts - U. S. citations

- More valuable patents are cited more
- One quarter of patents receive no citations
- 0.01% receive more than one hundred citations
- Lag distribution is skew to the left with a mode at about 3.5 years. Most cites happen by 10 years, but there can be long lags (30 years)
- Number per patent has increased recently with the advent of computerized search

EPO Citations

- Fewer in number (median around 3 instead of 6)
- Three types:
  - X – has potential to defeat novelty or inventive step when the reference is considered alone
  - Y – potential to defeat or refute inventive step when combined with one or more other such references - combination being obvious to a person skilled in the art
  - A - reference showing the general state of the art but would not be considered to be of particular relevance

NBER Patent Citations Data File

Available at http://www.nber.org/patents
http://emlab.berkeley.edu/users/bbhall/bhdata.html

~3 million U.S. patents granted between January 1963 and December 1999 (now updated to 2002)
- Patent number, application and grant dates
- Country and state of first inventor
- Main US patent class, number of claims
- Number of citations, forward and backward; generality and originality measures based on citations
- All citations made to these patents between 1975 and 1999 (over 16 million).
- Match of patenting organizations to Compustat (the data set of all firms traded in the U.S. stock market).
- Enables ownership assignment for part of the dataset.

Macgarvie (2003)

Other patent data

http://www.espacenet.com
- For EPO patent searching
http://www.european-patent-office.org
- For EPO data purchase (CD-Roms)
http://www.oecd.org/sti/ipr-statistics
- Contains triad (USPTO, EPO, JPTO) patents
- CD-Rom available from Colin Webb
- Complete statistical data from EPO

New project under Dominique Guellec (Chief Economist, EPO) to provide this on the web

Citations as indicators of knowledge flow

- Idea: if one patent cites an earlier patent, that implies that the knowledge or invention builds on or uses knowledge in the earlier patent
- Jaffe, Trajtenberg, Fogarty inventor survey (NBER)
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Applications of this idea

- "Self" measure in HJT
- Jaffe, Trajtenberg and Henderson (1993)
  - Measured geographic localization of knowledge spillovers
  - Compared citing patents to control patents with same technology and temporal distribution
  - Citing patents more likely to come from same locality as patent being cited
  - Citations used to measure knowledge flow induced by exporting or importing
  - Example: French firms begin exporting to Germany
    - Do they cite German patents more after than before?

Patents as value indicators

- Review earlier work on measuring innovation with patents briefly
- Hall, Jaffe, and Trajtenberg (RJE 2005)

Measuring innovation using patents

- Schmookler (1960 book) – pioneer in the use of patent statistics
- Scherer’s (1960s) work in oil, chemicals, steel
- Griliches et al. (~1980 incl. Hall) – first large sample work using computerized USPTO data. Conclusions:
  - Patents strongly related to R&D across firms, elasticity close to one
  - Controlling for unobserved differences across firms, elasticity lower (about 0.3)
  - Difficult to determine lag structure – R&D very smooth over time within firm
  - Poisson-type models – patents exhibit overdispersion
  - In the presence of R&D, patents add little explanatory power for sales, profits, market value, etc., Why?
Citations and market value

- Hall, Jaffe, Trajtenberg (2001/2004) – do patents weighted by forward citations provide a better measure of patent “value” than patent counts themselves?
- Broad firm-level analysis – previous studies invention- or narrow industry-specific:
  - Trajtenberg (RJE 1990) - consumer welfare for CAT scanners and citations
  - Klock and Shane (AER 1995) – market value of citation weighted patents in semiconductors
  - Austin (1993) - event studies on citation-weighted biotech patents

Market value equation

\[
\log Q_a = \log q_a - \log \left( 1 + \gamma_1 \frac{K_{t+1}}{A_t} + \alpha_4 D(K_{t+1} = 0) \right) + \epsilon_a
\]

where \( q_a = V_t / A_t \) (market to book or Tobin’s Q)

**Interpretation:**
- \( q_a \) = overall market level (approximately one),
- \( \gamma_1 \) = Relative shadow value of K assets (= 1 if depreciation correct, investment strategy optimal, and no adjustment costs).
- \( \alpha_4 \) = Premium or discount for the absence of K assets

Modified to accommodate patents and citations/patent:

\[
\log Q_a = \log q_a - \log \left( 1 + \gamma_1 \frac{R & D}{A_t} + \gamma_2 \frac{PAT}{A_t} + \gamma_3 \frac{CITES}{PAT} \right) + \epsilon_a
\]

Some measurement issues

- Patent stocks: \( P = \) no. of patents applied for at \( t \)
  - \( K(85) = (1-\delta) K(84) + P(85) \)
- Citation stocks: \( C = \) citations to patents applied for at \( t \)
  - \( K(85) = (1-\delta) K(84) + C(85) \)
- Past cite stocks: use only citations received by date of market value measurement

Exploratory power of knowledge stock measures

- Patents, Patents per R&D, R&D per Patent

Self citations

- Self-cites = citations to patents owned by the same firm.
  - More valuable => “owning” a technology
  - Less valuable => cite whatever is at hand, does not necessarily signify any value

Results

- High self-citation share is valuable (worth about twice as much) if firm is small or medium-sized, neutral if firm is large.
- Not having self cites is negative if firm is large, positive if firm is small.
Innovation surveys

- Widely used since mid-1990s
  - Based on Yale/CM surveys in US, but...
  - Now in EU countries; Chile, China,...
- Surveys at the firm or plant level
- Both quantitative and qualitative questions
- Cover a larger range of innovative activities than traditional measures

Input measures

- Source of innovation (firm, cooperation, joint)
  - Amount of cooperation
  - Use of public support
  - Innovation expenditure
    - Internal and external R&D; continuous?
    - Purchase of machinery & equipment
    - Related marketing/design expenditure
    - K purchase
    - Training related to innovation

Intermediate output measures

- New product introduction (to firm or market)
- New process introduction (to firm or industry)
- Share of new products in sales
- Organizational innovation

Qualitative measures

- Impetus/discouragement of innovation
  - Market factors (demand pull)
  - Cost factors and tech push
- Sources of knowledge
  - Suppliers, customers, regulation (standards)
  - Trade press, competitors, conferences
  - Public sector
- Methods for protection of returns
  - Informal: lead time, secrecy, confidentiality, complexity
  - Formal: trademarks, patents, copyrights, design registration

How to use these new data

- Most useful when combined with hard accounting data
  - Allows “concrete” performance measurement
- A number of studies of this kind
  - Crepon, Duguet, Mairesse (EINT 1997)
  - Special issue of EINT forthcoming (now on my website)
    - China, Chile, Scandinavia, Netherlands