Overview of my research on innovation

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Overview

• Broad themes
  ◦ Inputs: incentives for innovative activity by firms
  ◦ Outputs: measurement of innovation results

• Methodologies
  ◦ Microeconometric panel data studies
  ◦ Patent data analysis
  ◦ Largely firm-based

• Surveys
Drivers of innovation

- Science base
  - Research output of universities and PROs
- Human capital
  - Trained scientists and engineers
- Subsidies for R&D and commercialization
- Tax system and financing
  - Treatment of R&D; patent boxes
  - Financial system
- IP rights and the functioning of the IP system
- Regulatory environment
Subsidies

- **Hall, Link, & Scott**, looked at ATP research partnerships, focus on universities
  - More likely to be “new” science, subject to difficulty & delay, but not more likely to be terminated
  - Biggest contracting problem was negotiating IP rights

- **David, Hall, & Toole**, surveyed studies of additionality, finding ambiguous results
  - More likely additional in Europe and aggregate than in US and micro
  - Highlighted the implications of increased demand for S&Es

- **Hall & Maffioli**, surveyed results of Latin American programs
  - Subsidies generally increased R&D intensity (additionality)
  - Increased firm growth, but little other performance impact (productivity or patents), possibly because of short horizon
Choosing the level of R&D

- Profit-maximizing firm Invests in R&D until the after-tax marginal product of the resulting capital asset is equal to the tax-adjusted user cost of capital.

\[(1 - \tau)MPK = c_t = (1 - \tau)(1 - \varphi)(r + \delta)p_t - \dot{p}_t\]

- Therefore, R&D will depend on
  - Investor’s required rate of return \( r \)
  - (Economic) depreciation rate of the asset \( \delta \)
  - Marginal adjustment cost of R&D program (not shown)
  - Corporate tax rate \( \tau \)
  - Tax credits, if present \( \varphi \)

NB: if R&D is expensed and there is no special tax treatment, tax effects will not matter
R&D tax credits

- Hall (1992b) - first to use a theory-based investment equation and firm panel data to look at the impact of the R&D tax credit on R&D investment.
  - Modeled profit-maximizing firm facing adjustment costs on R&D and a price that depends on its tax position
  - Based on public firm data (not tax returns), so tax price of R&D inferred
  - Found large positive elasticities of R&D to its tax price (approx one or two)
  - Confirmed by much subsequent research, including cross-country (Hall and Van Reenen survey)
Financing R&D

- **Hall (1992a)** looks at the role of external financing (debt and equity) for R&D in US firms
  - Finds cash flow sensitivity (external finance more expensive than internal)
  - Equity preferred to debt for external financing
- **Hall and Hall (1993)**
  - Investors in US firms use lower discount rates for R&D, implying lack of short-termism
- **Mulkay, Hall, and Mairesse** compare firms in US and France
  - Greater sensitivity of R&D and investment to cash flow in US
  - No difference in response to output growth
- **Hottenrott, Hall, and Czarnitzki (2014)** – Belgian firms
  - Patents mitigate the cash flow constraint, especially for smaller firms
- Several surveys, some of which look at innovation more broadly
Measurement of output

- **Returns to R&D and innovation**
  - Innovative sales
  - Productivity
  - Firm growth
  - Firm market value

- **Use of patent data**
Returns to R&D and innovation

- Hall (2005) identified the centrality of the depreciation rate in measuring the returns or value of R&D
  - Found higher rates in IT than in pharmaceuticals
- Hall and Mairesse (1995)
  - Productivity of R&D in France strongly positive in 1980s
  - Explores several measurement issues (deprec, sales vs VA,..)
  - Employment growth comes equally from product innovation and increased sales of old products
  - Among SMEs, both process and product innovation improve productivity, more for process
  - Both R&D and ICT investment associated with innovation and productivity, with apparently high rates of return
Market value

- R&D and innovation are investments, so evaluation should use forward-looking measures.
- In countries with “efficient” and liquid capital markets, firm value may provide such a measure.
- Basic Tobin’s q relationship (hedonic equation):
  \[ V(\text{assets}) = \text{debt} + \text{equity} \]
  \[ = f(\text{capital, R&D capital, other intangibles}) \]
- But…“Past performance is no guarantee of future results.”
- => One should be cautious with interpretation.
Market value papers

• Hall (1993a,b) explores the decline in value of R&D in US corporations during 1980s
  ◦ Due to restructuring in manufacturing
  ◦ Writeoff of R&D assets in computing (PC revolution?)

• Hall, Oriani, Czarnitzki (various)
  ◦ Looks at R&D valuation in European firms

• Hall, Jaffe, Trajtenberg (2005); Hall, Thoma, and Torrisi (2010); Hall and MacGarvie(2010)
  ◦ Market value of various patent indicators (discussed later)
Patent system

- Two major research areas with very different aims and interests, but interrelated
  - **Normative** - patent policy and IP strategy
    - Existence and design of patent system – length, breadth
    - Firm strategic choices – secrecy, patenting, litigation, licensing
    - Enforcement and administration; interaction with antitrust
  - **Positive** - patents and citations as indicators
    - Measures of inventive output (rather than input)
    - Citations as measures of knowledge “spillover;” where we can identify the recipient as well as the source
Patent use and patent policy

- Hall and Ziedonis (2001)
  - Why did patenting rate in the semiconductor industry double between 1985 and 1995?
    - primarily for defensive reasons

- Hall (2005)
  - What are the sources of US patent growth 1965-2002?
    - Structural break in 1984 confined to ICT technologies
    - For US firms, growth concentrated in ICT industries, in all technologies

- Graham, Hall, Harhoff, and Mowery (2002)
  - Does post-grant third party opposition improve the quality or screening of patents?
    - Possibly, based on comparison of EPO opposition with US re-examination for “equivalent” patents
    - Valuable patents more often challenged, at least one third revoked and another third restricted
Patent use and performance

- Hall, Helmers, Rogers, and Sena (2013); Hall and Sena (2013)
  - Is use of patents or formal IP associated with UK firm performance?
    - Yes for productivity and innovative sales share
    - No for employment growth

- Hall, Helmers, and von Graevenitz (2013)
  - Do patent thickets discourage entry?
    - Yes, at least into patenting in the UK
Hall, Jaffe, Trajtenberg (2005)

- Relate firm market value to the stock of R&D, patents per R&D, and cites per patent.
  - Cites per patent are more important than patent yield itself
  - Increase of one cite per patent is associated with an increase of 3-4% in market value

- Break up cites per patent into five ranges: 0 to 4, 4 to 6, 6 to 10, 10 to 20, over 20
  - Only the latter three categories are positive; the other two are zero
  - 50-75% boost to market value if citations per patent average above 20!

- Timing – do citations received before value is measured matter more or less than those received after?
  - Less, although they are useful for forecasting.
  - Predictable and unpredictable citations receive approximately equal weight.
Self citations

- Self-cites = citations to patents owned by the same firm.
  - More valuable => “owning” a technology trajectory, cumulativeness is valuable
  - 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.
Surveys – R&D

- **Financing of R&D and innovation**

- **R&D**
Surveys - innovation

- Innovation and productivity

- Innovation and market value

- Innovation and diffusion
Surveys - patents

- Patents and patent policy

- IP choice (formal vs informal)

- IP and technology transfer