Overview of my research on innovation

Bronwyn H. Hall

UC Berkeley and University of Maastricht

NBER, IFS, and NIESR

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.

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

- Therefore, R&D will depend on
  - Investor's required rate of return *r*
  - (Economic) depreciation rate of the asset δ
  - Marginal adjustment cost of R&D program (not shown)
  - Corporate tax rate τ
  - Tax credits, if present (φ)

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 v VA,..)
- Hall, Lotti, and Mairesse (2008, 2009, 2012) – Italian firms
  - 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(assets) = debt+equity

  = f(capital, R&Dcapital, 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 "equivlaent" 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
  - Hall & Lerner (2010). The Financing of R&D and Innovation. In Hall & Rosenberg, Handbook of the Economics of Innovation, Elsevier, 609-639.
  - Hall (2009). The Financing of Innovation, European Investment Bank Papers 14 (2): 1-23.
- R&D
  - Hall (2011). The Internationalization of R&D. In Sydor (ed.), Global Value Chains: Impacts and Implications, Ottawa, Canada: Foreign Affairs and International Trade Canada, 179-210.
  - David, Hall, & Toole (2000). Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence. Research Policy 29: 497-529.
  - Hall & van Reenen (2000). How Effective are Fiscal Incentives for R&D? A New Review of the Evidence. Research Policy 29: 449-469.
  - Hall (1996). The Private and Social Returns to Research and Development: What Have We Learned?. In Smith & Barfield (eds.), Technology, R&D, and the Economy, Washington, DC: Brookings Institution and AEI

Surveys - innovation

- Innovation and productivity
  - Hall and Mohnen (2013). Innovation and Productivity: An Update. *Eurasian Business Review* 3(1): 47-65.
  - Hall (2011). Innovation and Productivity, *Nordic Economic Policy Review* 2011 (2): 167-204.
- Innovation and market value
  - Hall (2000). Innovation and Market Value. In Barrell, Mason, and O'Mahoney (eds.), *Productivity, Innovation and Economic Performance*, Cambridge: Cambridge University Press, pp. 175-198.
- Innovation and diffusion
  - Hall (2004). Innovation and Diffusion. In Fagerberg, Mowery, and Nelson (eds.), *Handbook of Innovation*, Oxford University Press.

Surveys - patents

- Patents and patent policy
  - Hall and Harhoff (2012). Recent Research on the Economics of Patents. *Annual Review of Economics* 4: 541-565.
  - Hall (2007). Patents and Patent Policy. *Oxford Review of Economic Policy* 23 (4): 1–20.
- IP choice (formal vs informal)
  - Hall, Helmers, Rogers, and Sena (2014). The choice between formal and informal intellectual property: A literature review. *Journal of Economic Literature* 52(2): 375–423.
- IP and technology transfer
  - Hall (2014). Does Patent Protection Help or Hinder Technology Transfer?. In S. Ahn, B. H. Hall, and K. Lee (eds.), *Intellectual Property for Economic Development: Issues and Policy Implications*, Edward Elgar.