

Determinants of innovative performance: insights from economics

Prof. Bronwyn H. Hall
University of California and
University of Maastricht

Innovative performance

► Innovation:

- the first attempt to put a new product or process into practice (Fagerberg, Mowery, and Nelson, Oxford Handbook of Innovation, Chapter 1)
- the introduction of a new product or process to the market
- commercialization of an invention

► Performance:

- of an economy, sector, or firm
- growth, profitability, productivity

Limitations

- ▶ Is invention an economic phenomenon?
 - In many cases, no
 - especially radical inventions
- ▶ However, making invention into successful innovation requires
 - Money
 - A market – willing buyers
- ▶ => subject to economic analysis

Basic economics of innovation

▶ Starting point (**Nelson and Arrow**):

Innovation is the production of new information, which implies

- Increasing returns within the firm (“natural monopoly”)
 - Nonrival - more than one firm can use it at the same time
 - Nonexcludable – cannot prevent others from using it
- ▶ All this creates a number of problems for policy and business strategy, even though they do not hold in their extreme form

Overview

- ▶ Determinants of innovation
- ▶ Economic evidence
 - mostly using R&D and patents as proxies for innovative activity
- ▶ New findings from innovation surveys

Determinants

- ▶ Classifying the determinants of innovation
 - Supply
 - ▶ Cost
 - ▶ Market structure and appropriability
 - Demand
 - Environment – government and institutions
- ▶ *NB: All these factors imply a number of policy levers*

Supply of innovation

- ▶ Cost of capital (interest rates, tax subsidies, etc.)
 - Corporate governance
- ▶ Venture capital availability
 - Skilled investors
 - Exit possibilities (financial markets)
- ▶ Cost and availability of trained scientists and engineers
- ▶ “technological opportunity”; public research sector

Cost of capital for R&D investment

- ▶ R&D tax credits are effective in increasing R&D in many countries (usually “dollar for dollar”)
- ▶ Less evidence on their effects on innovative output
 - preliminary results for US suggest increased patenting
- ▶ Market value of R&D assets suggests private depreciation rates of around 15-35%
- ▶ In some countries (notably the UK), required rate of return to R&D can be quite high
- ▶ We know less about other types of innovation investment (now collected by survey, but reporting limited)

Venture capital

- ▶ Even in the US, supplies a small share of capital for investment, but that share is important
- ▶ “contracting structure developed to manage the extreme uncertainty, information asymmetry, and agency costs that inevitably bedevil early-stage, high-technology financing” (Gilson, *Stanford Law Review*, 2003)
- ▶ Three pillars (all essential):
 - Source of capital
 - specialized financial intermediaries
 - entrepreneurs
- ▶ However, across countries, VC availability explains very little once we control for income level

Public research sector

- ▶ In many instances, innovation relies on scientific knowledge
- ▶ Such knowledge has a “public good” nature and is often the output of publicly funded research (either in public or private institutions)
- ▶ Developing effective links between such organizations and inventors/innovators seems to be a difficulty identified by many government policy makers

Market structure; appropriability

- ▶ Firm size
- ▶ Market share
- ▶ Competitive pressure (domestic or global)
- ▶ Position in value chain – commodity or differentiated product?
- ▶ Appropriability – ability to capture value via IPRs or other means

Market structure and innovation

- ▶ Large economic literature, theoretical and empirical concludes that there is an inverted u-shaped relationship
 - Perfect competition leaves no profits for investing in innovation
 - Monopoly that is not threatened by entry has no incentive to innovate
 - Between the two, innovation first increases (due to increasing market share) and then decreases (due to lack of competitive threat)

Appropriating returns to innovation

- ▶ Survey evidence in the US rates the following in importance for securing returns to innovation:
 - Lead time, first mover advantage
 - Secrecy
 - Complementary sales/service
 - Patents (more important in chemicals)
- ▶ Recently importance of patenting appears to have risen
 - Probably for defensive reasons

Demand for innovation

- ▶ Market size
- ▶ Consumer tastes
 - Willingness to adopt something new
- ▶ Needs of downstream firms
 - Demand for improved inputs

Environment

- ▶ Macro economy (stability; exchange rates)
- ▶ Regulatory environment
- ▶ Education system
- ▶ Public-private research interaction
- ▶ Standard setting
- ▶ => "national innovation system"

What do we know?

- ▶ Considerable information on individual factors
 - Earlier work based on R&D/patent data
 - Newer work using innovation survey data
- ▶ Less on how they work together (mostly qualitative or very aggregate evidence)
 - Cross country studies
 - Some work on policy complementarity

Cross country results

► Furman, Porter, Stern (RP 2002):

- Measured innovation by patents
- Varies one-for-one with population, FTE S&Es, R&D, GDP, or lagged patents across countries, high explanatory power
- Best model includes GDP per capita, stock of patents, R&D spending or personnel, educ share of GDP, IP strength, private R&D share, univ R&D share, and degree of specialization of economy, explains 98% of variance across countries

Innovation surveys

- ▶ Pioneered in US by Nelson, Cohen, Levin, Winter, et al. (Yale, CMU surveys)
- ▶ Now widespread:
 - EU countries (CIS surveys)
 - Canada, Australia, New Zealand
 - Norway, Switzerland, Russia, Turkey
 - Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay, Venezuela
 - South Korea, Taiwan, Singapore, Malaysia, Thailand, Japan, China
 - South Africa

Next few slides from Mairesse-Mohnen survey (in progress 2007)

Survey measures

- ▶ Innovation:
 - Product or process new to market (yes/no)
 - Share of sales from new products
- ▶ Demand pull/technology push:
 - Weak, moderate, strong effect on innovation activities (according to firm)
- ▶ Productivity – sales per worker, or TFP

Next four slides summarize some findings from the surveys

What have we learned?

- ▶ On determinants of innovation
 - probability of innovating increases with firm size
 - intensity of innovation is constant or decreasing with firm size
 - incumbents tend to innovate more and innovation is persistent within firms
 - demand pull often significant and positive
 - technology push positive, less often significant
 - ▶ (controlling for industry)
 - R&D, especially continuous R&D, matters for innovation

What have we learned? (2)

- ▶ R&D-productivity revisited
 - CDM model of R&D \Rightarrow innovation \Rightarrow productivity
 - estimated for ~12 countries
 - confirmed rates of return to R&D found in earlier studies
 - innovation output statistics are much more variable (“noisier”) than R&D, as was found for patents
 - ▶ need to be instrumented by R&D

What have we learned? (3)

- ▶ Crowding-out or additionality of government support for innovation
(e.g., Czarnitski, Duguet, Arvanitis, Hall and Maffioli, etc.)
 - Matching estimators or simultaneous modeling of government support and firm performance
 - Most studies find additionality
 - Mixed evidence on performance (positive for Germany, less so for Latin America)

What have we learned? (4)

- ▶ Complementarities (supermodularity: the whole is more than the sum of its parts) between
 - different types of innovation, e.g. product and process innovation (Miravete and Pernías 2006)
 - internal and external technology sourcing (Cassiman and Veugelers 2002)
 - different types of cooperation strategies (Lokshin, Belderbos, Carree 2005)
 - internal skills and cooperation (Leiponen 2003)
 - However, results are mixed and heavily dependent on the appropriate correction for unobserved heterogeneity
- ▶ Complementarity of innovation policies (Mohnen-Roeller) – results suggest that policy choice among financial/skill availability/regulatory) should be
 - Joint to encourage firm to begin innovation
 - Single to encourage increase in innovation intensity

Innovation systems

- ▶ More examples of interaction effects:
 - Effective VC requires thick financial market for exit
 - Good tertiary education does not produce much industrial innovation if the people trained are channeled into secure govt lab jobs
 - R&D tax credits may not be effective if firms do not feel competitive pressure to innovate
 - Rapid increases in research funding tend to raise salaries of S&Es (whose supply is inelastic in the short run), somewhat reducing their real effectiveness

Final remarks

- ▶ A welcome innovation - the new inventor survey approach
 - Related to the innovation surveys but focused on inventors rather than firms
 - Pioneered in Europe
 - Now in Japan and US
 - Look forward to an excellent conference and to learning about the first comparative results