R&D, innovation, and productivity

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Questions

• Do R&D and innovation contribute to the productivity growth of firms, industries and countries?
• Do R&D and innovation contribute to the productivity growth of other firms, industries, and countries?
• If so, what policies are effective for encouraging these activities?
• What other factors in the environment matter for innovation?
• Specific question for this seminar: How can policy be designed to capture challenges facing a nation with downsizing incumbents and increased importance of new entrepreneurial firms?
Outline

• Innovation-productivity nexus
• R&D vs innovation
• What is known about R&D and innovation in relation to productivity
  – Brief digression on interpretive framework
• R&D policy
• Broader policy framework
Innovation and productivity

- What are the mechanisms connecting innovation and productivity?
  - Improvements within existing firms
    - Creation of new goods & services, leading to increased demand for firm’s products
    - Process and organizational innovation leading to efficiency gains in production
  - Reallocation of resources towards “better” firms
    - Entry of more efficient or new product firms
    - Entry of firms on technology frontier
    - Exit of less efficient firms

November 2016 Stockholm seminar
R&D vs innovation

• Not all innovative firms do formal R&D
• R&D-doing firms do not innovate every year (or even every 3 years)

<table>
<thead>
<tr>
<th>Italian firms 1995-2006</th>
<th>Non-innovator</th>
<th>Innovator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not do R&amp;D</td>
<td>30.9%</td>
<td>34.8%</td>
</tr>
<tr>
<td>Does R&amp;D</td>
<td>6.2%</td>
<td>34.3%</td>
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• Especially true in the service sector:
  – Many innovations are not technological, such as new ways of organizing information flow, new designs, etc.
  – Many innovations rely on purchased technology, such as adoption of computer-aided processes, CRM software, etc.
Measuring innovation

• Large literature using R&D flows or stocks as proxies for innovation input
  – Hall, Mairesse, Mohnen 2010 survey, *inter alia*

• Smaller literature using patents as a proxy for intermediate innovation output

• Both measures have well-known weaknesses, especially outside the manufacturing sector.
  – Most surveys of the service sector find many innovating firms, fewer R&D-doers

• Now we have more direct measures – used by a number of researchers
Innovation surveys contain.....

- **Data on innovation:**
  - Product or process new to firm/market (yes/no)
  - Share of sales during past 3 years from new products
  - More recent surveys have expenditures on various kinds of innovation investments

- **Data on productivity and employment:**
  - Usually sales per worker (labor productivity)
  - Sometimes TFP (adjusted for changes in capital)
  - Issues arising from deflation and level of aggregation
    - • of goods, and of enterprises

**More information in Mairesse and Mohnen (2010)**
R&D vs innovation spending

- UK firms on the CIS 1998-2006 – average breakdown of spending on innovative activities.
- Service sector firms spend more on new equipment and marketing and less on R&D.

<table>
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<tr>
<th>Acquisition of machinery &amp; computer hardware/software</th>
<th>Manufacturing</th>
<th>Services &amp; other</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>43.2%</td>
<td>47.0%</td>
</tr>
<tr>
<td>Internal R&amp;D spending</td>
<td>25.1%</td>
<td>12.0%</td>
</tr>
<tr>
<td>Marketing expense</td>
<td>10.6%</td>
<td>16.5%</td>
</tr>
<tr>
<td>Training expense</td>
<td>5.4%</td>
<td>13.4%</td>
</tr>
<tr>
<td>Design expense</td>
<td>8.8%</td>
<td>4.2%</td>
</tr>
<tr>
<td>External R&amp;D spending</td>
<td>4.2%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Acquisition of external knowledge</td>
<td>2.6%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Share with nonzero innov. spending</td>
<td>71.1%</td>
<td>54.7%</td>
</tr>
</tbody>
</table>

The shares shown are for firms that have some form of innovation spending reported.
What do we know?

• A great deal about
  – the contribution of R&D and innovation to firm-level productivity as conventionally measured
  – The contribution of R&D and innovation to the productivity of other industries and countries

• Something about
  – The contribution of entry of more efficient and exit of less efficient firms to aggregate productivity growth
  – The contribution of R&D to quality improvement and therefore productivity growth (via lower prices)

• Much less about
  – Contribution of R&D and innovation to welfare and to poorly measured but important outputs (health, environmental quality, etc)
  – Aggregate growth implications in detail
Interpretive framework

• Innovation-productivity regressions use revenue productivity data
  – Include coarse sectoral dummies
  – Relative within-sector price changes not accounted for
  – Quality change not generally accounted for

• Omitting price change at the firm level can be helpful, as it allows estimation of the contribution of innovation to firm demand as well as efficiency

• Hall (2011) - analysis of the implications of distinguishing productivity from revenue productivity
Productivity-innovation model

• Innovation will affect both the price the firm can charge and the quantity it produces from a given set of inputs
• Output measure -- revenue (sales) -- incorporates the joint response of price*quantity to product and process innovation
• Assume the following:
  – Imperfect competition (positive markup; downward sloping demand with constant elasticity)
  – Process innovation reduces cost (same inputs produce more)
  – Product innovation shifts demand curve out (higher willingness to pay for the same good, or higher quality good for the same price)
Conclusions from analysis

• Product innovation unambiguously increases revenue productivity and labor demand

• Process innovation will increase revenue productivity and labor demand only if demand is elastic; even in this case impact is dampened unless there is perfect competition (price taking)

• Allocation of the impact of innovation between price and quantity will depend on the type of price deflator used
  – the closer the deflator is to a true quality-adjusted price, the higher the measured innovation contribution to quantity rather than price (with a corresponding negative effect on price).
  – However, estimates of the innovation impact on firm revenue are not affected
Product vs process

• Can one distinguish between innovative activity directed toward
  – new/improved products (increased demand) vs.
  – new/improved processes (increased efficiency)?
• Yes - work by Petrin and Warzynski (2011) provides some evidence that the product/process distinction is meaningful
  – Danish micro data on wood products and iron & steel
  – R&D at the product/process level within firm.
  – Allows estimation of the contribution of R&D to demand (quality improvement) and technical efficiency separately
  – Finds product R&D more related to quality improvement and process R&D more related to technical efficiency
  – Work in progress
Spillovers

• Principle argument for R&D/innovation policy is the presence of unpriced spillovers to firms that are adjacent in industry, technology, or geographically.

• Lots of evidence that this is true ([Kao et al 1999, Keller 1998, 2001, Coe and Helpman 1995]). Some nuances:
  – Spillovers from foreign R&D more important for smaller open economies than for countries like US, Japan, and Germany ([Park 1995, van Pottelsberghe 1997])
  – Domestic spillovers usually larger than those from other countries ([Branstetter 2001, Peri 2004])
  – Absorptive capacity of recipient country is important for making use of R&D spillovers ([Guellec and van Pottelsberghe 2001])
  – Typical social rates of return are quite large, but very imprecisely determined
R&D policy

• Main policies (widely used)
  – Property rights (at the cost of restricted output)
  – Subsidies (often targetted; high administration costs)
  – Tax credits of various kinds
• Brief summary of evidence
  – IP important in some (but definitely not all) sectors
  – Subsidies have a mixed record, but mostly positive in the sense that they increase R&D spending by the firm
  – R&D tax credits unambiguously increase R&D spending, usually with price elasticity around unity
• With the exception of some subsidy programs, all of these policies target the private rate of return, not the social

- 13 EU countries, Japan, Canada, and US for 1980-1998
- Public, private, & foreign R&D all contribute to MFP growth
- Factors affecting this relationship are
  - absorptive capacity (own business R&D increases elasticities)
  - funding origin – small countries benefit more from foreign R&D
  - govt objectives - nondefense contributes more to productivity of business R&D
  - type of public R&D institution – universities vs government laboratories.
- Uses reasonable econometric methods but results may be sensitive to precise specification
R&D and innovation policy

- Some governments have turned to IP or patent boxes in order to broaden supported activities.
- However, R&D tax credits *strongly preferred* to patent boxes for a number of reasons:
  - Directly related to cost of activity (firm decisions)
  - Relative size of non-R&E budget does not affect credit (depending on box design)
  - No incentive to choose projects with high non-R&E expenses (depending on box design)
  - No tax subsidy for patent trolling
  - No incentive to use zombie patents to reduce taxes
  - Less arbitrage across firms possible – doesn’t matter who does the R&D
  - Lower audit cost
Broader policy context

• Innovative activity (including diffusion) affected by many things, not all of which are viewed as susceptible to “innovation policy”
  – Timely bankruptcy procedures and contract enforcement
  – Entry costs and regulation
  – Product market regulation
  – Labor market regulation – startups need flexibility
    • Corollary: lifetime training availability
  – Political resistance from affected firms and workers
Institutions and innovation

• Availability of data on these regulatory measures has led to research that looks at the implications for innovative activity and the efficiency with which resources are re-allocated, leading to productivity growth

• **Barbosa and Faria (2011)** – look at product/process innovation in 2002-2004 in 10 European countries
  – Product and labor market regulation affects innovation intensity negatively
  – More developed credit markets foster innovation
  – Strengthening of intellectual property rights does not seem to stimulate innovation

• **Ciriaci et al. (2016)** – Above a threshold of PMR, EPL is negative for R&D location.
Product market regulation in 2013 and threshold value for EPL impact (EU 28)

- PMR measure from OECD includes 1) state control; 2) barriers to trade and investment; 3) barriers to entrepreneurship
Allocative efficiency & regulation (AE)

- Can resources (capital and workers) move to their most productive use?
- **Andrews & Cingano (2014)** – controls for endogeneity of policies
  - Higher barriers to entry and creditor-friendly bankruptcy legislation tend to lower AE
  - Tighter employment protection lowers the efficiency of employment allocation
  - Stringent product & labor market regulation, bankruptcy legislation more disruptive to AE in innovative sectors
• Industry-country study for 14 OECD countries, 18 industries, both mfg and services
  – Impact of non-mfg regulation, harmonized tariffs and EPL on MFP is negative
  – For Sweden, EPL dominates

- Productivity gaps between national frontier and global frontier firms smaller in countries where
  - education systems are of higher quality;
  - product market regulations are less cumbersome;
  - businesses and universities collaborate intensively;
  - markets for risk capital are more developed.
- Mixed results on patent strength: lower gap in R&D intensive sectors, but not in more dynamic sectors

- Country-industry results:
  - Lower PMR associated with higher MFP growth for firms in industries with high firm turnover rates,
  - Lower EPL associated with higher MFP growth for firms in industries with high job turnover rates,
  - Higher R&D collaboration between universities and firms is associated with higher MFP growth for laggard firms in K-intensive industries
Cross-country gains to aggregate labour productivity from reforms to best practice level of four policy variables that partly explain cross-country industry differences in the size of national frontier (NF) firms, relative to global frontier (GF) benchmark.

Source: Andrews et al. (2015)

Sweden does fairly well, except for EPL
Summary

• Do R&D and innovation contribute to the productivity growth of firms, industries and countries? **YES**
• Do R&D and innovation contribute to the productivity growth of other firms, industries, and countries? **YES**
• If so, what policies are effective for encouraging these activities? Subsidies, tax credits, and IP? Not IP boxes
• What other factors in the environment matter for innovation? PMR and EPL, macro economy (uncertainty)
• How can policy be designed to capture challenges facing a nation with downsizing incumbents and increased importance of new entrepreneurial firms?
  – Main message of the institutional framework literature is that Sweden’s EPL may limit or discourage the needed worker re-allocation
Thank you for listening
(a bit more on aggregate effects below)
Aggregation

- How does individual firm relationship aggregate up to macro-economy?
  - productivity gains in existing firms
  - exit and entry
  - Competition and entry encourages innovation unless the sector is very far behind
- Djankov (2010) survey – cross country
  - stronger entry regulation and/or higher entry costs associated with fewer new firms, greater existing firm size and growth, lower TFP, lower investment, and higher profits
Entry and exit

• **Olley & Pakes, Haltiwanger & co-authors** have developed decompositions that are useful

• **Foster, Haltiwanger, and Syverson (2008)** – US data
  
  – Distinguish between revenue and quantity, and include exit & entry
  
  – Revenue productivity understates contribution of entrants to real productivity growth because entrants generally have lower prices
  
  – Demand variation is a more important determinant of firm survival than efficiency in production (consistent with productivity impacts)
Future work?

- Full set of links between innovation, competition, exit/entry, and productivity growth not yet explored
- **Bartelsman et al. (2010):** Size-productivity more highly correlated within industry if regulation is “efficient”
  - Evidence on Eastern European convergence
  - Useful approach to the evaluation of regulatory effects without strong assumptions
- Similar analysis could assess the economy-wide innovation impacts