Policy for innovation: insights from economic research

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Overview of talk

• The Puerto Rican context
• Determinants of innovative activity
  – Policy levers
  – Economic evidence
• Some findings from innovation surveys
Context – Puerto Rico

• Included in state-level data in NSF’s *Science and Engineering Indicators*, but much of the data is noncomparable and therefore missing
  – Lower Federal R&D/civilian worker than any state
  – Lower share of computer workers than any state
  – Academic R&D less productive (papers or patents)
• First R&D survey provides data on R&D activities
  – R&D-GDP ratio is 0.5%; lower than almost all US states; comparable to larger LA countries (except Brazil) and some Eastern European countries
  – 2/3 is business R&D; 91% of that in US affiliates
• Supplement with patent data on the next few slides
• Is there an innovation survey yet?
Top patenting organizations in PR

<table>
<thead>
<tr>
<th>Assignee name</th>
<th>Patent grants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hewlett-Packard Development Company, L.P.</td>
<td>153</td>
</tr>
<tr>
<td>General Electric Company</td>
<td>152</td>
</tr>
<tr>
<td>University of Puerto Rico</td>
<td>95</td>
</tr>
<tr>
<td>Checkpoint Systems, Inc.</td>
<td>50</td>
</tr>
<tr>
<td>International Business Machines Corporation</td>
<td>50</td>
</tr>
<tr>
<td>Stryker Instruments</td>
<td>47</td>
</tr>
<tr>
<td>Commonwealth of Puerto Rico</td>
<td>32</td>
</tr>
<tr>
<td>Ethicon, Inc.</td>
<td>31</td>
</tr>
<tr>
<td>Baxter International Inc.</td>
<td>30</td>
</tr>
<tr>
<td>E. I. Du Pont de Nemours and Company</td>
<td>27</td>
</tr>
<tr>
<td>Vassallo Research &amp; Development Corporation</td>
<td>23</td>
</tr>
<tr>
<td>Aventis Pharmaceuticals Inc.</td>
<td>20</td>
</tr>
<tr>
<td>Telik, Inc.</td>
<td>20</td>
</tr>
<tr>
<td>Lear Corporation</td>
<td>18</td>
</tr>
<tr>
<td>Bristol-Myers Squibb Company</td>
<td>17</td>
</tr>
<tr>
<td>United Technologies Corporation</td>
<td>17</td>
</tr>
<tr>
<td>Cardiac Pacemakers, Inc.</td>
<td>16</td>
</tr>
<tr>
<td>US government</td>
<td>16</td>
</tr>
<tr>
<td>Gaymar Industries, Inc.</td>
<td>15</td>
</tr>
<tr>
<td>Merck &amp; Co., Inc.</td>
<td>15</td>
</tr>
<tr>
<td>Sepracor Inc.</td>
<td>15</td>
</tr>
<tr>
<td>Remaining organizations</td>
<td>624</td>
</tr>
<tr>
<td>Unassigned</td>
<td>497</td>
</tr>
</tbody>
</table>

Note: almost all are PR or US-based

Yellow entries are pharma-biotech
What is innovation?

• The first attempt to put a new product or process into practice (Fagerberg, Mowery, and Nelson, *Oxford Handbook of Innovation*, Ch. 1)

• The introduction of a new product or process to the market

• Commercialization of an invention

• *Innovation survey definition*: a good, service or process new to the firm (or market) introduced during the past 3 years
Some preliminary considerations

• Is invention an economic phenomenon?
  – In many cases, no
  – especially radical inventions

• However, making invention into successful innovation requires
  – Money
  – A market with willing buyers

• => subject to economic analysis
Determinants

Classifying the determinants of innovation:

1. Supply
   a. Cost (of capital, inputs, science base)
   b. Market structure and appropriability

2. Demand

3. Environment – government and institutions

*NB: All these factors imply a number of areas that policy could influence*
1a. Cost of capital

• Financing innovation
  – required rate of return to R&D can appear to be quite high in some countries
  – especially for SMEs

• Reasons:
  – Uncertainty and risk
  – Lack of clear property rights or collateral
  – High depreciation rates for R&D assets - market value of firms’ R&D assets implies private depreciation rates of around 15-35%

• Know less about other types of innovation investment
  – Purchase of new technology; training; marketing expense
  – now being collected by survey, but analysis limited so far
1a. Policies to reduce innovation costs

- R&D tax credits – firm chooses projects
  - Effective at increasing R&D in many countries (usually one for one)
  - Tend to favor large established firms with profits
  - Less evidence on their effects on innovative output
    - NB: if goal is to compensate for externalities, private return may fall
  - R&D tax credits may not be effective if firms do not feel competitive pressure to innovate (Canadian case?).
1a. Policies to reduce innovation costs

• Subsidies and grants – government chooses projects
  – Many but not all studies find additionality of government support for innovation (surveys by Hall and Maffioli, Klette et al., David et al.)
  – Mixed evidence on performance (sometimes positive for Europe, less so for Latin America) - lack of long time series
  – 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 (evidence for US, OECD).
Figure 1. Direct government funding of business R&D and tax incentives for R&D, 2011

As a percentage of GDP

http://dx.doi.org/10.1787/888932891112
1a. Venture capital

- A “contracting structure developed to manage the extreme uncertainty, information asymmetry, and agency costs that inevitably bedevil early-stage, high-technology financing” (Gilson, 2003)
- Three pillars (all essential):
  - Source of capital
  - Specialized financial intermediaries
  - Entrepreneurs
- Effective VC requires thick financial market for exit (some notable failures in this area).
- Highly cyclical; sector specific
- Even in the US, VC supplies a small share of capital for investment, but that share is important
- However, across countries, VC availability explains very little once we control for the country’s income level
1a. People

• Education system
  – Availability of highly trained scientists and engineers in the relevant discipline
  – Flexibility in training – the ability to retrain in a different (possibly related) field
    • Example – need for computer and data science methods in modern biotechnology
  – However, tertiary education does not produce much industrial innovation if the people trained are mainly channeled into secure govt lab jobs (e.g., some Latin American countries).

• Immigration policies
  – Help to solve supply bottlenecks in S&E
  – Can be a source of entrepreneurs, as in the US
1a. Public research sector

- Some innovation relies on scientific knowledge
- This knowledge often the output of publicly funded research (either in public or private institutions)
- Developing effective links between such organizations and inventors/innovators and bridging the gap between invention and commercialization - weakness identified by many government policy makers, including those in US.

Are all countries “below average” in performance?
Or is commercialization simply a very difficult process?
University-industry interactions

- Industry rates engineering more important than science, except for chemistry
- Best information sources according to industry – papers, conferences, consulting, not patents (except in Japan)
- Firms committed to open innovation more likely to access university science
- Evidence that local university research matters for local firms
- Recent survey by Foray and Lissoni (2011)
Industry-university links in the US - evidence

• Faculty incentives & participation important
  – Obtaining invention disclosure a function of share retained by researcher
  – Participation in startup helps to predict its success
  – More successful researchers start firms
  – Entrepreneurial researchers also publish more, even after startup
• Only the best technology transfer offices cover their costs
1b. Market structure

- 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)
1b. Appropriating returns - policy

• Property rights on intangibles:
  – Patents (ordinary and utility models)
  – Trademarks
  – Design rights
  – Copyright

• Trademarks are the most commonly used

• Firms tend to use several, even for the same product

• Central policy problem is the conflict between the social benefits of widespread use of the intangible and the social cost of poor incentives for its production
1b. Appropriating returns - evidence

Survey evidence from US and Europe rates importance for securing returns to innovation in this order:

• Lead time, first mover advantage
• Secrecy
• Complementary sales/service
• Patents
  – Only ~10% of respondents rate them first or second
  – Exceptions: pharmaceuticals, specialty chemicals, medical instruments, auto parts
  – Recently importance of patenting appears to have risen.
    • Probably for defensive reasons
    • Also because of the “knowledge economy” and increased importance of intangibles
2. Demand for innovation

• Market size
  – A benefit for large economies, such as US and China
  – For small economies, thinking outside the country very important – export-oriented firms tend also to be more innovative in most countries

• Consumer tastes
  – Needs
  – Willingness to try something new

• Needs of downstream firms
  – Demand for improved inputs

• Government – defense, health, energy, etc
  – Has played an important role in the US at least since 1945
3. Institutional environment

- Macro economy (stability; exchange rates)
- Regulatory environment
  - E.g., firm entry regulation; technological mandates such as fuel economy
- Property rights, both real & intellectual
- Educational system
- Functioning of the public-private research interaction
- Standard setting process

All this adds up to a “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
  – Could be useful to take a more “systems” approach to analysis
Innovation surveys

• Pioneered in US by Nelson, Cohen, Levin, Winter, et al. (Yale, CMU surveys)

• Now widespread around the world:
  – 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
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 three slides summarize some findings from the surveys (from Mairesse and Mohnen 2011)
What have we learned? (1)

• On determinants of innovation:
  – probability of innovating increases with firm size
  – intensity of innovation is constant or decreasing with firm size
  – demand pull often significant and positive
  – technology push positive, less often significant (controlling for industry)
  – R&D, especially continuous R&D, matters for innovation
  – However, many firms innovate without doing R&D, especially in services
  – Innovation associated with interaction with other firms and customers
What have we learned? (2)

• R&D-productivity revisited
  – \textbf{CDM} model of R&D $\Rightarrow$ innovation $\Rightarrow$ productivity
  – estimated for $\sim$15 countries
  – confirmed rates of return to R&D found in earlier studies
  – Like patents, innovation output statistics are much more variable ("noisier") than R&D
  – Product innovation strongly associated with revenue productivity; process innovation much less so
What have we learned? (3)

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
• internal and external R&D
  – Lokshin, Belderbos, Carree 2005
• internal skills and cooperation
  – Leiponen 2003

However, results can be somewhat mixed and heavily dependent on the appropriate correction for unobserved heterogeneity across firms
Thank you for listening

Questions?