Policy for innovation: insights from economic research

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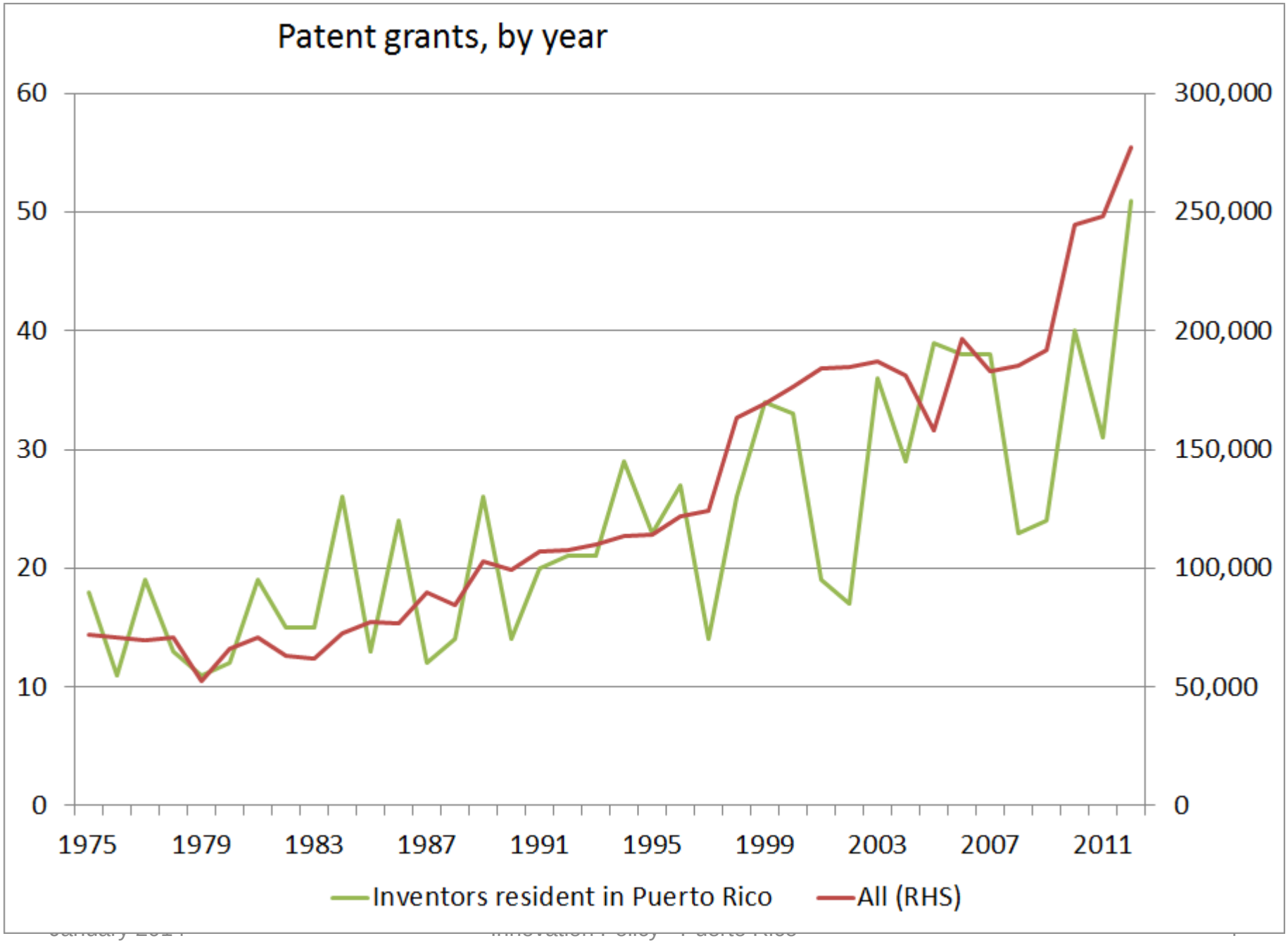
Overview of talk

- 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
  - See M. Lobato Vico*, Science and Technology Survey* (2009).
  - 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?


Patent grants, by year
60
50
40
30
20
10
0
300,000
250,000
200,000
150,000
100,000
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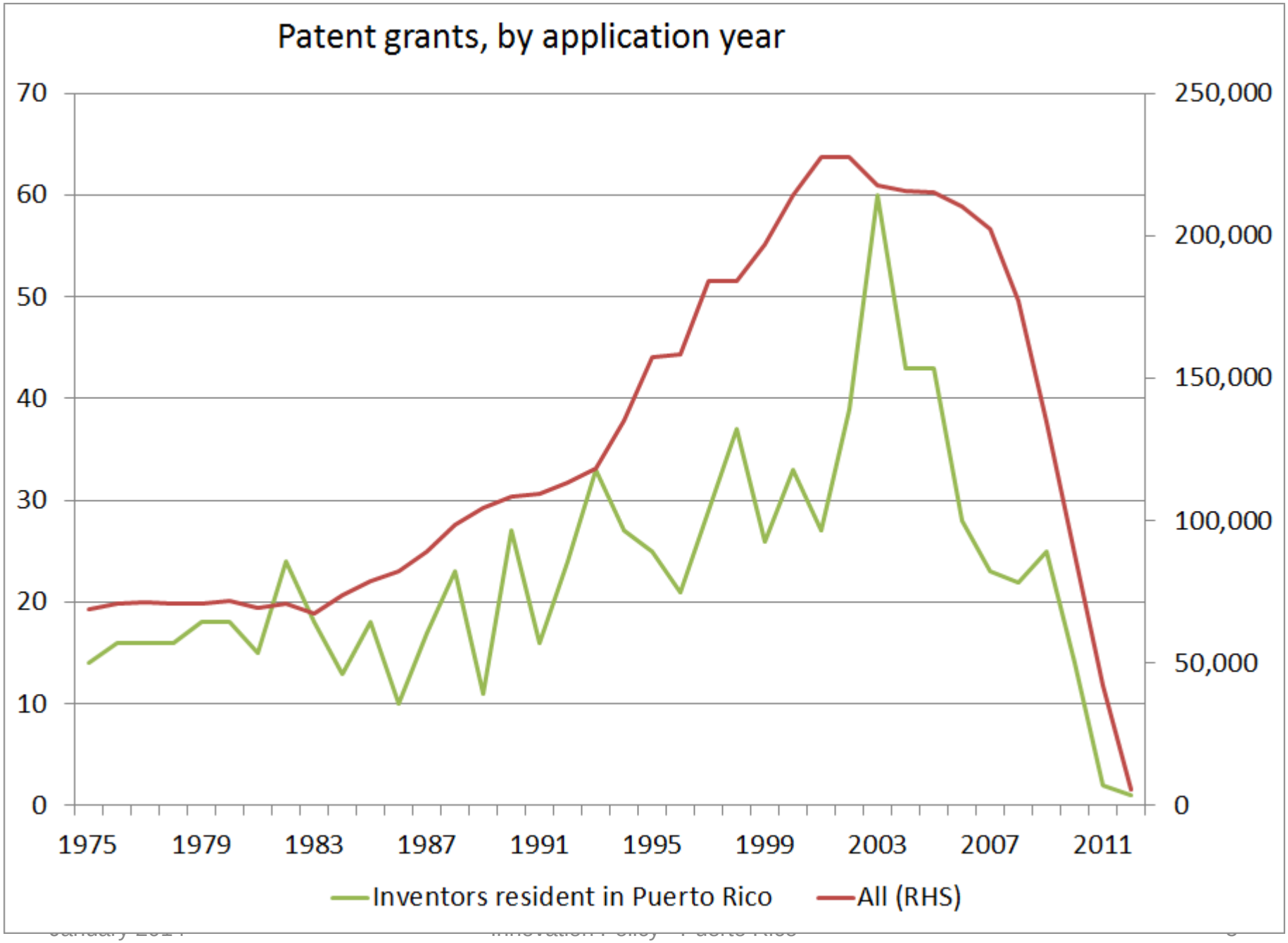
0
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
Inventors resident in Puerto Rico
All (RHS)


Patent grants, by application year
70
60
50
40
30
20
10
0
250,000
200,000
150,000
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1975
1979
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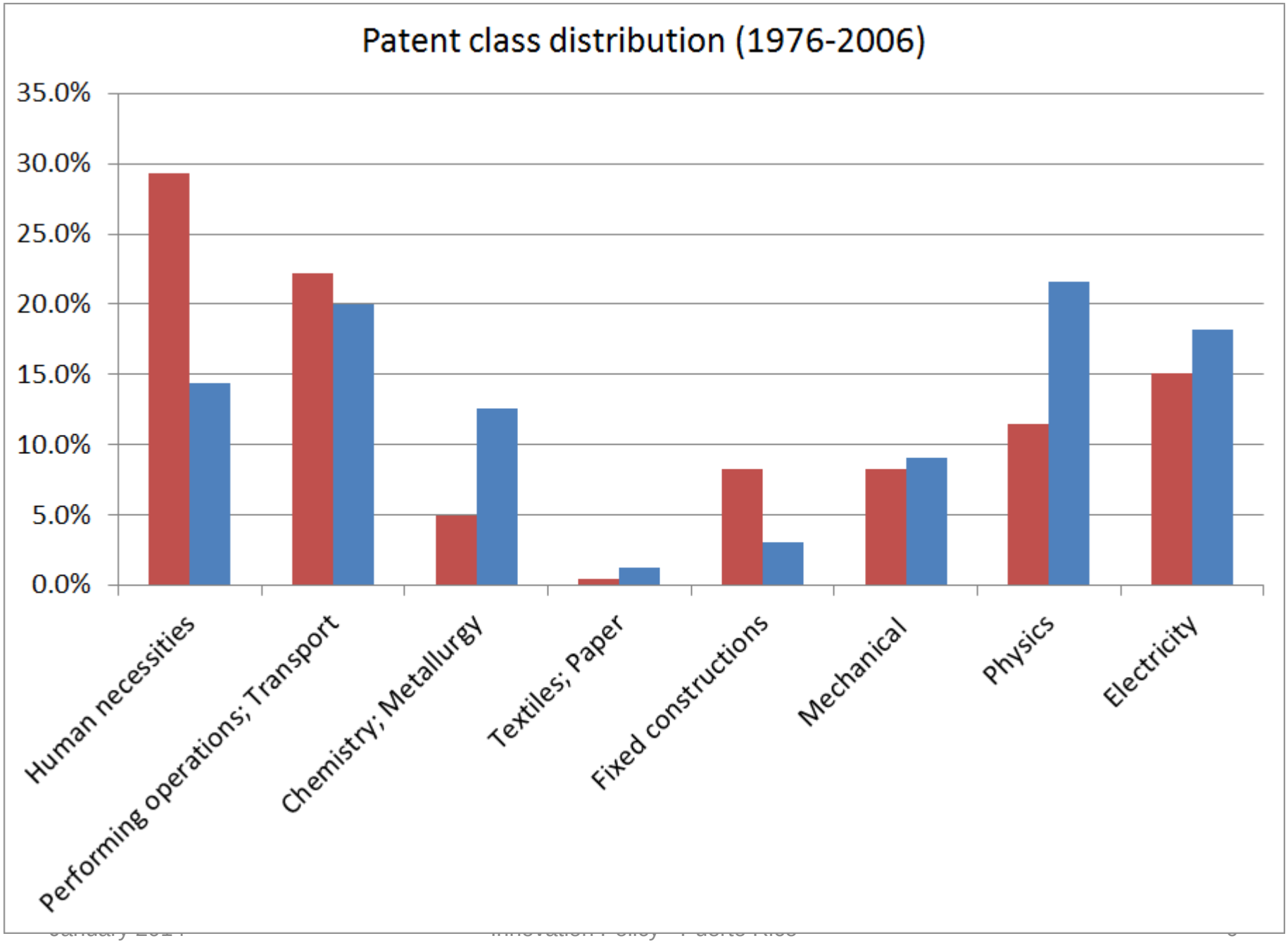

Patent class distribution (1976-2006)
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Human necessities
Performing operations; Transport
Chemistry; Metallurgy
Textiles; Paper
Fixed constructions
Mechanical
Physics
Electricity

Top patenting organizations in PR

Note: almost all are PR or US-based

Yellow entries are pharma-biotech

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

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

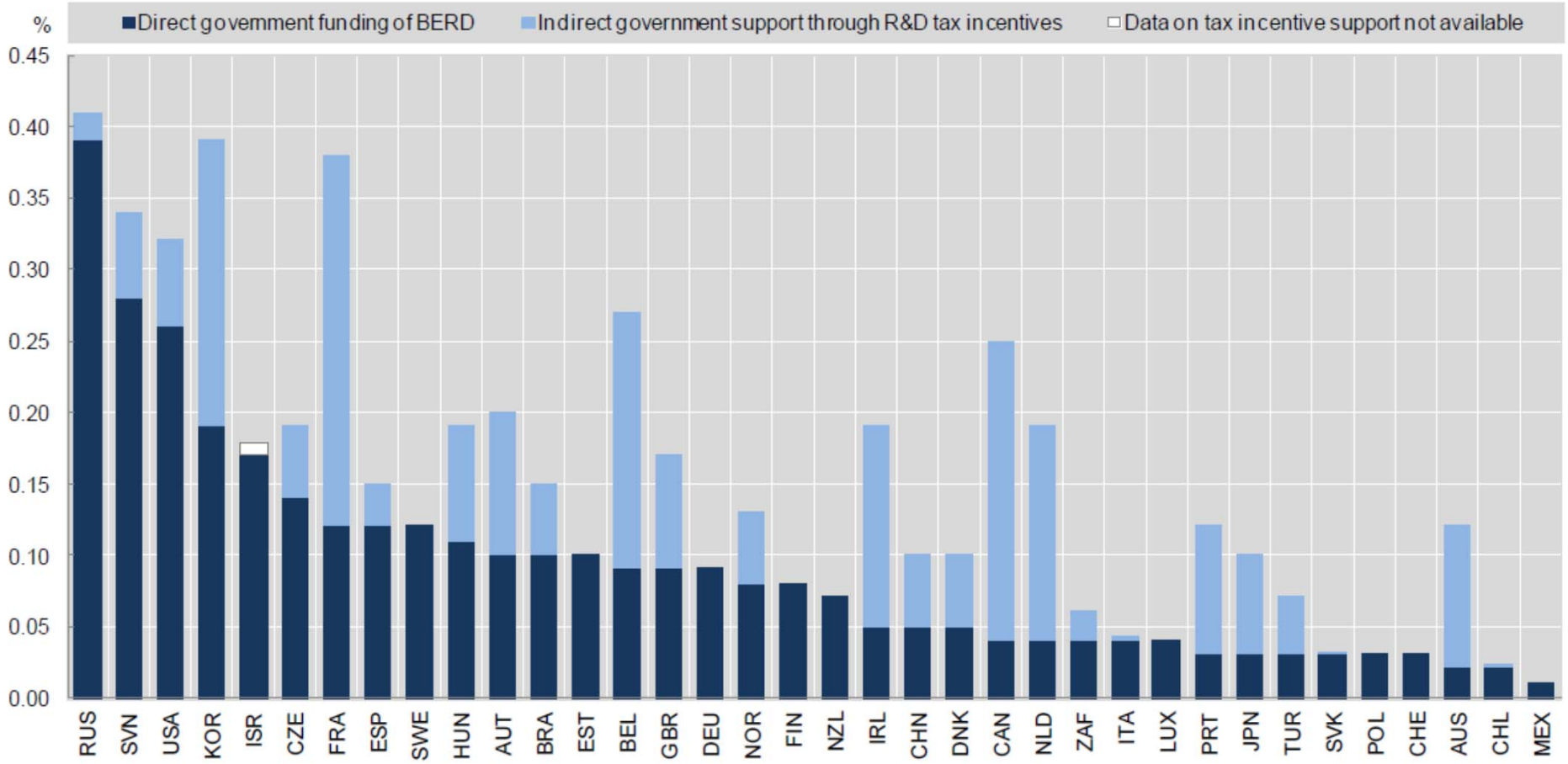
- R&D tax credits – firm chooses projects
  - Effective at increasing R&D in many countries (usually one for one)
  - Tend to favor large established firms with profits
  - Less evidence on their effects on innovative output
    - NB: if goal is to compensate for externalities, private return may fall
  - 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



StatLink 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
  - CDM model of R&D $\Rightarrow$ innovation $\Rightarrow$ productivity
  - estimated for ~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?