New Technology Indicator

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Motivation

- Demand for internationally comparable measures of innovation and technology is increasing; however, it is difficult to develop such measures (Hall and Jaffe, 2012).

- Existing measures (Keller, 2010):
  1. R&D investments (input)
  2. Patents (output)
  3. Total Factor Productivity (TFP, effect of technology)

- All those measures have drawbacks. For example, it is difficult to construct comparable measures of TFP and comparable data are often not available.
Methodology

- The paper proposes an alternative indicator of technology: R&D depreciation rate (Li and Hall, 2016 for detailed methodology)

- R&D depreciation rate depends on technological progress and degree of market competition (Hall, 1997)

- Technology leaders in the U.S. have smaller R&D depreciation rates than followers (Li, 2015).

- This paper shows that technological advantage is associated with lower R&D depreciation rates across countries when there is free trade between countries.
Model for R&D Depreciation

- The paper proposes a model for estimating R&D depreciation rates.
- The estimates are derived from a profit maximization of a firm from investment in R&D.
- The firm chooses R&D to maximize the PDV of the future stream of income from R&D:
  
  \[
  \text{Profit} = \text{PDV of future income from R&D} - \text{R&D}
  \]
Model for R&D Depreciation

- It is assumed that future profits from R&D decline at a rate equal to R&D depreciation rate. (?)

- The depreciation can be solved from the profit maximization. It is a function of R&D intensity, output growth and R&D growth.
Data

- Countries: the U.S., China, Germany, S. Korea, and Japan

- Industries: motors; pharmaceutical, computer; electronic & optical products; and electrical equipment industries.

- Period: The majority of the data cover the decade of the 2000s, but China’s data is shorter because it started reporting R&D investments in 2006.

- Sources: BEA, Japan’s Cabinet Office, OECD, and CEIC datasets.
R&D Intensity

Pharmaceutical

Computer/Electronic/Optical

Motors

Electrical/Machinery
### Country Comparison: Pharmaceutical and Medical Device Industry

<table>
<thead>
<tr>
<th>Country</th>
<th>$\delta_{RD}$</th>
<th>$\delta_{RD}$ Ranking</th>
<th>Forbes’ Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>12%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Japan</td>
<td>14%</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Germany</td>
<td>20%</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>China</td>
<td>52%</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>South Korea</td>
<td>89%</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
## Country Comparison: Motor Industry

<table>
<thead>
<tr>
<th>Country</th>
<th>$\delta_{RD}$</th>
<th>$\delta_{RD}$ Ranking</th>
<th>Forbes’ Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>19%</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Japan</td>
<td>20%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>United States</td>
<td>35%</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>South Korea</td>
<td>43%</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>China</td>
<td>52%</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
# R&D Depreciation and TFP growth: the U.S. and Japan

<table>
<thead>
<tr>
<th>Industry</th>
<th>$\delta_{\text{RD, US}}$</th>
<th>$\delta_{\text{RD, Japan}}$</th>
<th>$\text{TFP}_{\text{US}}$</th>
<th>$\text{TFP}_{\text{Japan}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical equipment Industry</td>
<td>20%</td>
<td>26%</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Computer, electronic, and optical products industry</td>
<td>16%</td>
<td>23%</td>
<td>19.5</td>
<td>15</td>
</tr>
<tr>
<td>Pharmaceutical industry</td>
<td>12%</td>
<td>14%</td>
<td>1.05</td>
<td>0.9</td>
</tr>
<tr>
<td>Motors industry</td>
<td>35%</td>
<td>20%</td>
<td>1.1</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Time-Varying R&D Depreciation vs. TFP

Industry-Level TFP 1955-2010
- Catching up in manufacturing sectors
Time-Varying R&D Depreciation vs. TFP

Industry-Level TFP 1955-2010
- Catching up in manufacturing sectors

Computer, Electronic, and Optical Products

Year

US
Japan

Industry-Level TFP 1955-2010
- Catching up in manufacturing sectors
Conclusion

- Countries are different in technology.

- Based on data for four high-tech industries in five countries, the new indicator shows promising results.

- The new indicator is easier to construct and provides of cross-country comparison of technology.
Discussion of the Paper
Main Findings of the Paper

- The paper shows that R&D depreciation provides an alternative indicator of technology.

- The paper shows that the indicator provides a sensible indicator of technology across countries.
Comments and Suggestions

- Comments and suggestions on the model.
- Comments and suggestions on the results
The main assumption: profit rates decline over time at the constant rate which is equal to the depreciation rates of R&D asset.

The paper should compare its definition with more standard definition of depreciation in the SNA: depreciation is the loss of R&D asset values as the asset ages. The depreciation occurs even when the profits are constant over the asset life as the service life of the asset becomes shorter with ages.
Comments on the Results

- The paper derives an equation for the depreciation rate as a function of three main variables: R&D intensity, output growth and R&D growth.

- It will be useful to show how the depreciation changes with those 3 variables and the intuition behind the relationship. I did that: R&D depreciation is a function of R&D intensity (-), output growth (+), and R&D growth (+). The link on R&D intensity and R&D depreciation explains the sensible results in the paper.
Comments on the Results

- It will be useful to provide more discussion about the main result that a lower depreciation rate is an indicator of more rapid technological progress.

- A counter example for that result: as rapid technological process makes old technologies obsolescence, deprecation rates tend to higher.
Comments on the Results

- The paper should make it clear whether R&D depreciation is an indicator of levels or changes in technologies.