Working Party on National Accounts

Depreciation of business R&D Capital

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OECD Conference Centre
Beginning at 9:00 a.m. on the first day

This document will be presented under item 4 of the draft agenda

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Depreciation of Business R&D Capital

Brent Moulton (Paper prepared by Wendy Li)
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Background

- Most R&D is conducted on own account and is often not capitalized in an enterprise’s own financial accounts

- Because R&D assets are unique and rarely sold, data on age-price profiles are not available

- Methods for deriving depreciation profiles:
  - Patent renewals – But not all R&D assets are patented
  - Surveys or expert opinions – But service lives vary across industries and types of R&D
  - Profits or market value of R&D owner
New method of estimating depreciation rates
  - Allows variation between industries and over time

Premise:
  - R&D capital depreciates because its contribution to firm profitability declines over time
  - Firms are assumed to maximize the present discounted value of the returns to R&D investments

Data:
  - Compustat (company-based): R&D investments and sales
  - BEA-NSF (establishment-based): R&D investments and industry outputs
Model

\[
\max_{\pi_i} \pi_i = \text{ - present cost} + \text{ present discounted value of returns to R&D investments}
\]

\[
= -RD_i + \sum_{j=0}^{J-1} \frac{q_{i+j+d} I(RD_i)(1-\delta)^j}{(1 + r)^{j+d}}
\]

where

- \(RD_i\): R&D investment amount in period \(i\).
- \(q_i\): sales in period \(i\).
- \(I(RD_i)\): percentage increase in profits due to R&D investments.
- \(\delta\): R&D depreciation rate.
- \(d\): gestation lag (assumed to be an integer which is \(\geq 1\)).
- \(j\): a number large enough to cover the length of service lives of R&D assets.
- \(r\): cost of capital
Impact of R&D on Profits

Profile of Profit Rate Increase Due to R&D Investments

\[ I[RD] = I_\Omega \left( 1 - \exp \left[ \frac{-RD}{\theta} \right] \right) \]

\( I'(RD) > 0, \quad I''(RD) < 0 \)

\[ \log \theta = \log \theta_{2000} + \alpha(t - 2000) \]
Implementing the Model

- Because sales for periods after \( i \) must be forecasted, a time series of sales data is modeled as an autoregressive (AR) process.
- Because the forecast error affects the depreciation rate, forecast errors were estimated using Monte Carlo methods and added to the forecast values.
- Compustat (company) data for 1989–2008 used for nine industries; BEA-NSF data for ten industries.
- Set \( j = 20 \) (25 for pharmaceuticals); \( d = 2 \); \( r = 8.9\% \).
Industry-specific, Time-varying R&D Depreciation Rates (Compustat)

Note: The vertical bars are the standard deviations of estimated R&D depreciation rates resulting from the uncertainty in forecasted sales.
Industry-specific, Time-varying R&D Depreciation Rates (BEA-NSF)

- Computers and peripheral equipment manufacturing
- Communication equipment manufacturing
- Semiconductor and other electronic component manufacturing
- Software publishing
- Navigational, measuring, electromedical, and control instruments manufacturing
- Scientific research and development services
- Pharmaceutical and medicine manufacturing

Year
R&D Depreciation Rate [%]
## Summary of (Static) Depreciation Rates

<table>
<thead>
<tr>
<th>Industry</th>
<th>Compustat</th>
<th>BEA-NSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers and peripheral equipment</td>
<td>.38</td>
<td>.41</td>
</tr>
<tr>
<td>Software</td>
<td>.30</td>
<td>.24</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>.12</td>
<td>.08</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>.18</td>
<td>.27</td>
</tr>
<tr>
<td>Aerospace products and parts</td>
<td>.61</td>
<td>.45</td>
</tr>
<tr>
<td>Communication equipment</td>
<td>.28</td>
<td>.31</td>
</tr>
<tr>
<td>Computer system design</td>
<td>.29</td>
<td>.43</td>
</tr>
<tr>
<td>Motor vehicles</td>
<td>.40</td>
<td>.62</td>
</tr>
<tr>
<td>Navigational, measuring, electromedical and control instruments</td>
<td>.34</td>
<td>.26</td>
</tr>
<tr>
<td>Scientific research and development</td>
<td>NA</td>
<td>.16</td>
</tr>
</tbody>
</table>
## Summary of Depreciation Rates Based on BEA-NSF Dataset

<table>
<thead>
<tr>
<th>Industry</th>
<th>(\delta (d=2))</th>
<th>(\delta (d=0))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers and peripheral equipment</td>
<td>0.41</td>
<td>0.40</td>
</tr>
<tr>
<td>Software</td>
<td>0.24</td>
<td>0.20</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>0.27</td>
<td>0.25</td>
</tr>
<tr>
<td>Aerospace</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>Communication equipment</td>
<td>0.31</td>
<td>0.28</td>
</tr>
<tr>
<td>Computer system design</td>
<td>0.43</td>
<td>0.36</td>
</tr>
<tr>
<td>Motor vehicles, bodies and trailers, and parts</td>
<td>0.28</td>
<td>0.29</td>
</tr>
<tr>
<td>Navigational, measuring, electromedical, and control instruments</td>
<td>0.26</td>
<td>0.29</td>
</tr>
<tr>
<td>Scientific research and development</td>
<td>0.16</td>
<td>0.15</td>
</tr>
</tbody>
</table>

\(d\) refers to the gestation lag of a typical R&D investment and \(\delta\) refers to the depreciation rate of the R&D investment.
Conclusions

- Developed an R&D investment model
  - Estimation results are robust

- Estimated static results align with conclusions from other recent studies.

- Provided industry-specific, time-varying R&D depreciation rates.
  - Example – Since 2000, IT hardware R&D has had shorter product life cycle, higher R&D depreciation rate.

- R&D depreciation rates in pharmaceuticals are overall lower than those of other industries