The decline of research in corporate R&D

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Motivation

- Corporate investment in research accounts for 22% of all basic research in the United States, and nearly 30% of all basic plus applied research in the United States

- Many fundamental scientific discoveries have been made by industrial labs
  - Clinton Davisson shared the 1937 Nobel Prize in Physics for demonstrating the wave nature of matter
  - John Bardeen, Walter H. Brattain, and William Shockley received the 1956 Nobel Prize in Physics for inventing the first transistor
  - William C. Campbell and Satoshi Ōmura shared with Youyou Tu the 2015 Nobel Prize in Physiology or Medicine for discovering “a new drug, Avermectin, the derivatives of which have radically lowered the incidence of River Blindness and Lymphatic Filariasis, as well as showing efficacy against an expanding number of other parasitic diseases”
Motivation

• Anecdotal evidence indicates that many corporate labs have been closed, downsized or redirected towards more applied research
  – Bell Labs downsized from 30K employees to less than 1K by August 2008 (Lerner, 2012: 42)

The rise and fall of corporate R&D
Out of the dusty labs

Technology firms have left the big corporate R&D laboratory behind, shifting the emphasis from research to development. Does it matter?

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IN THE waning days of the second world war, Vannevar Bush, science adviser to President Franklin Roosevelt, penned a report that served as the blueprint for what would become America’s enormously successful information-technology industry in the second half of the 20th century. With the grandiose title “Science, The Endless Frontier”, Bush (no relation to the current president) laid out a vision for government-funded science and engineering that would unite academia, industry and (this being wartime) the armed forces. This it achieved by, in effect, keeping them apart.
Motivation

- Anecdotal discussions of proximate and distal causes: Short-termism; China; Division of innovative labor, ...
Roadmap

• Are (large) firms withdrawing from investing in science?
  • Publication data
  • Investment data
  • Europe?
  • Sector differences?

• Why?
  • Value or cost?

• Is research still relevant for invention?

• What about start-ups?
Main findings: Less “R” more “D”

**Stylized fact 1:** Large firms investing less in research
- Decline is concentrated in basic rather than applied journals; unlikely to be driven by changes in publications behavior

**Stylized fact 2:** Private value declines
- Investors (and managers) pay for the fruit of science (patents) but not for the golden goose itself (the firm’s scientific capabilities)

**Stylized fact 3:** Robust patterns
- Results are present in broad range of industries

**Stylized fact 4:** Research continues to be useful for invention
- Especially corporate research

**Stylized fact 5:** Start-ups are not picking up enough of the slack
1. **U.S. Compustat.** Investment and stock market value for R&D performing publicly-listed firms.

2. **Scientific publications.** Publications by firms (312k)
   – Automatic and manual match of Compustat and SDC to Thomson Web of Science (affiliation field)

3. **Patents.** Match USPTO and EPO patents to Compustat and SDC Platinum (M&A data)

4. **Acquisitions.** 29,752 acquisitions from Thomson SDC for the period 1985-2007
   – Deal value, shares acquired, assets, sales, industry
   – 2.5k publications and 115k patents
   – Track post-acquisition behavior

Our data on publication and patenting by firms and use of science by firms are available at the Golden Goose Project online platform, funded by NSF (SciSIP): [http://goldengoose.aipatents.com/CorpScience/companyData](http://goldengoose.aipatents.com/CorpScience/companyData)
Business funded and performed research in the United States, 1953-2015, NSF S&E Indicators

Broad pattern: Less “R”, more “D”: Investment
Broad pattern: Less “R”, more “D”: Investment
Within industrial sector patterns

Share of basic and applied research by industry
1996-2013

Source: NSF Science and Engineering Indicators

Note: The figures present the share of basic and applied research in total domestic R&D paid and performed by companies. The data is based on NSF’s Survey of Industrial Research and Development (SIRD) for 1996-2007 and the Business R&D and Innovation Survey (BRDIS) since 2008, which provide information on type of R&D by character of work: basic research, applied research, and development. Industry classification is based on SIC codes (1996-1998) and NAICS codes (1999-2013): Chem&Pharma- SIC 28 and NAICS 325; Electr&Semicond- SIC 357 & 36 and NAICS 334; Machinery- SIC 351–56 & 358–59 and NAICS 333.
Using publication data allows us to
• match to firms,
• adjust for changes in economic structure (e.g., changing mix of industries)
• trace use of research (e.g., citations received from patents)
• extend analysis to Europe, private firms,..
• also useful for managerial analysis
Publication per firm: European firms, 1980-2007

Broad pattern: Less “R”, more “D”. Trends also evident in Europe

*Note:* The figure presents per firm per year publications over time for European firms. Annual publication is conditional on publishing firms. European regions are based on United Nations classification.
Are (large) firms withdrawing from investing in science?

Why?

- Value or cost?
  - Supply-side (e.g., more costly scientist) or demand-side (e.g., tougher competition) effect?

Is research still relevant for invention?

What about start-ups?
Changes in value of science (to the firm) vs. changes in the costs of science

Value (to firm) of Marginal Product of science

Marginal cost of science

VMP\(0\)

VMP\(1\)

MC\(0\)

MC\(1\)

Q\(_{0}\)

Q\(_{1}\)

Q\(_{2}\)
Decline in private value of research:
The value of publications has dropped and the value of patents has increased over time for both investors and managers.

Estimates of elasticity of market value with respect to publication and patent stocks over time, 1980-2006.

Note: The estimates are from regressing stock market value against firm’s assets, R&D stock, publications stock, patents stock, and a complete set of dummies for year and industry. The sample consists of firms with at least one patent and one publication. The sample period is 1980–2006.

Note: This figure presents estimates of elasticity of acquisition value with respect to publication and patent stocks by year cohorts for acquired firms. The estimates are from regressing stock market value against firm’s assets, sales, publications stock, patents stock, and complete set of dummies for year, industry codes, target country and acquisition year. The sample includes all SDC Platinum deals with complete information on target firm value, assets, and sales. The sample period is 1985–2007.
Roadmap

• Are (large) firms withdrawing from investing in science?
• Why?

• Is research still relevant for invention?
  • Use of corporate vs public research
  • Who uses corporate research
  • Use of internal research

• What about start-ups?
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**Stylized fact 4:** Research continues to be useful for invention
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**Stylized fact 5:** Start-ups are not picking up enough of the slack
And yet, science remains useful for invention: Patents cite science at higher rates over time while the age of the cited science remains constant.

Average age of science cited in patents and average cites per patent, 1980-2006

Note: This figure presents average publication age of cited articles by patents (NPL) and share of citations to science per firm-year for our sample firms. Cited publication age is the difference between patent grant year and year of publication of the cited article. Scientific citation share is the ratio between patent citations to leading scientific journals and the total number of references the patent makes.
A corporate publication is six times more likely to be cited by a patent than a university publication.

Use of University vs. Corporate Publications, 1980-2006

(A) Mean comparison for citation per publication

![Bar chart showing mean comparison for citation per publication with Diff: 0.68**.]

(B) Cumulative probability

![Cumulative distribution plots for Pharma & Drugs, Chem, IT & Computers, Biotech.]

(C) Avg. citations per publication

![Graphs showing average citations per publication with corporate publications being six times more likely to be cited by a patent than university publications.]

Note: The sample includes publications from the top 100 U.S. universities and corporate publications of our sample firms that were published over the sample period (1980-2006) and covered in Web of Science "Science Citation Index" and "Conference Proceedings Citation Index-Science". Patent citations per publication is measured by total citations received from all patents (corporate and non-corporate) granted between 1980 and 2014. Figure A presents mean comparison for university vs. corporate publications by patent citation received per publication. Figures B and C plot the cumulative distribution of patent citations received per publication, by corporate and university publications.
Who uses corporate science?

Notes: The sample includes all cited scientific publications published by our sample firms (at least one author employed by the firm) between 1980 and 2006 and cited through 2006. Large and Small Compustat firms are publicly traded US firms with above and below an average of $50m annual sales over the sample period, respectively. Internal citations consist of citations by a firm’s patents to publications where at least one author is employed by the same firm.

http://goldengoose.aipatents.com/CorpScience/companyData
Corporations are using more science, especially external science, over time

Trends in citation to science by patents of U.S. public corporations 1986-2006

Note: The figures presents trends over time in citations by patents of U.S. publicly traded R&D performing firms to scientific publications. The sample is conditional on patenting firms with at least one publication. Internal citations per patent are citations to the publications with at least one author employed by the firm. In figure A, internal citation is presented as a ratio of total NPL citations. NPL citations are patent citation to the non-patent literature. Internal citations per patent are multiplied by 10 for ease of viewing. In figure B, internal citation is presented as a ratio of total citations to corporate science. Corporate science includes any publications with at least one author employed by our sample of corporate firms.
• Are (large) firms withdrawing from investing in science?
• Why?
• Is research still relevant for invention?

• **What about start-ups?**
  – *We wanted flying cars, instead we got 140 characters* Peter Thiel
Start-ups increasingly focus on D rather than R

Note: Figure A presents total annual flow of publications and patents over time for U.S. VC-funded patenting firms. Figure B presents annual publications and patents per firm over time for U.S. VC-funded patenting firms. The sample consists of U.S. VC-funded firms, first funded between 1980-2006. Publication and patents in any year are from any VC-funded firm receiving initial funding in the previous five years (excluding firms that have gone public). VC investment in a given year is total VC funding received by startups in the A round. VC data is from SDC Platinum VentureXpert database. Scientific publications include all articles published by our sample firms between 1980 and 2006, and covered in Web of Science "Science Citation Index" and "Conference Proceedings Citation Index-Science". The analysis is based on a set of 5K firms, out of which 1.5k firms were identified as patenting firms (have at least one patent in the first five years after first investment) and are included in the analysis. An addition 15K firms are being processed for analysis.
VC-backed firms use science more intensively than corporations, mostly because they are more likely to be in science-intensive sectors.

Note: Figure B plots the residuals from regressing separately for corporate and VC funded firms, citations to public science and citations to corporate science (per firm per year) on a set of industry dummies. The sample consists of U.S. VC-funded firms, first funded between 1980-2006. Publication and patents in any year are from any VC-funded firm receiving initial funding in the previous five years (excluding firms that have gone public). VC investment in a given year is total Round A VC funding received by startups in that year. VC data is from SDC Platinum VentureXpert database. Scientific publications include all articles published by our sample firms between 1980 and 2006, and covered in Web of Science "Science Citation Index" and "Conference Proceedings Citation Index-Science". The analysis is based on a set of 5K firms, out of which 1.5k firms were identified as patenting firms (have at least one patent in the first five years after first investment) and are included in the analysis. An addition 15K firms are being processed for analysis.
Conclusions

• Large firms are withdrawing from research, the research continues to be relevant for invention
  – Large firms are investing less in research, and the stock market value of research is declining
  – Same patterns are reflected in acquisition price
  – Share of research in business R&D has declined
  – Decline in private value of research rather than increase in cost
  – Patents (esp corporate patents) cite science at increasing rates

• Pessimistic interpretation: Private research is in decline
  – Established companies can no longer emulate firms such as DuPont, AT&T, IBM, or Merck
  – VC-backed firms are not adequate substitute for “missing” corporate research
  – Corporate research different from public research
  – Increased importance of public funding? Short-termism? China? ..

• Less pessimistic interpretation: A division of innovative labor
  – Established firms source inventions from universities, often through start-ups
  – Reallocation of research from large corporate labs to more efficient and specialized research organizations (e.g., universities)
  – Is the division of innovative labor between public research, start-ups, and corporations working?
  – Strategic challenge for corporate management?