Innovation in the U.S. Federal Government

Joshua Bruce
University of Illinois at Urbana-Champaign

John de Figueiredo
Duke University

Presented at the NBER Conference on The Role of Entrepreneurship and Innovation in Economic Growth, January 2020 in Mountain View, CA
Short Outline

• Summary
• The Federal Government
• Classification of Innovation in the Federal Government
• Technological Innovation Inputs
• Technological Innovation Outputs
• Diffusion of Innovation
Government Innovation: Summary

• Innovation in the Government is split into two parts
  • Hard science/engineering type of innovations (technological)
    • These outputs are easier to measure
  • Social science type of innovations (organizational, regulatory, policy)
    • These outputs are harder to measure

• Scientists
  • Hard scientists/engineers dominate the Department of Defense (DOD)
  • Social and other scientists are more equally represented in non-DOD agencies

• Budgets (Mainly Hard Science)
  • ~50% of Federal R&D budget goes to DOD; Non-DOD R&D budget goes mostly to Health and Space research
  • ~75% of Federal R&D budget directed externally to Higher Ed, FFRDCs, & Business
    • ~25% of Federal R&D budget directed internally (intramural)
Government Innovation: Summary

• Government-Assigned Patent Output (Hard Science/Engineering)
  • The quantity of government-assigned patents looks like a large firm (TI, DuPont)
  • The areas in which the government patents
    • Biggest areas: Medical Science; Biochemistry; Measuring and Testing; Calculating and Counting
    • Biggest market share of patents: Defense-Related (Manufacturing Explosives; Ammunition Fuses; Explosive Charges; Radio-Based Navigation; Materials Analysis)
  • Government-assigned patents, relative to corporate-assigned patents in a technology class, are:
    • Slightly more original (novel); Slightly more general; Less cited

• Diffusion of Innovation (very, very preliminary)
  • Technical innovations start in an agency and tend to follow one of three paths
    • Stay in the agency
    • Diffuse across technical agencies
    • Diffuse across the government

• To understand innovation in the federal government, measuring the scope and impact of non-technological innovations is important
Brief Literature Review

• Taxonomy of Government Innovation: Hartley (2005); Hartley et al (2013); Chen et al (2019); de Vries et al (2016); Bommert (2010); Edquist (2012);


• Defense/FFRDCs R&D: Trajtenberg (2006); Mowery (2012); Moretti et al (2019); Chen (2014); Bonvillian (2018); Jaffe and Lerner (1999)

• Diffusion: de Vries et al (2018); De Francesco (2012)
Federal Government Budget

Federal Government Outlays (2018 Dollars)

Source: FY2020 Historical Tables, Budget of the United States, OMB; BLS CPI

Outlays by Agency 2018

Social Sec: $987B
Medicare: $588B
Military (exR&D): $554B
Health Care (exVA): $511B
Net Interest: $324B
Federal Government Employees

<table>
<thead>
<tr>
<th>Branch</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Branch Civilian</td>
<td>2,061,248</td>
</tr>
<tr>
<td>Postal Workers:</td>
<td>585,530</td>
</tr>
<tr>
<td>Uniformed Military</td>
<td>1,401,715</td>
</tr>
<tr>
<td>Judicial Branch</td>
<td>32,711</td>
</tr>
<tr>
<td>Legislative Branch</td>
<td>30,010</td>
</tr>
<tr>
<td><strong>Total Federal Employees</strong></td>
<td><strong>4,111,307</strong></td>
</tr>
</tbody>
</table>

Source: FY2020 President’s Budget of the United States, OMB; OPM CPDF-EHRI
Federal Government Employees

**Figure 2:** Distribution of GS Grades Over Time.

Source: FY2020 President’s Budget of the United States, OMB; OPM CPDF-EHRI
Federal Government Employees

Figure 7: Changing Nature of Federal Work.

Source: FY2020 President’s Budget of the United States, OMB; OPM CPDF-EHRI
## Classification of Innovation in the Federal Government

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Concept</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological</td>
<td>Technically or technologically new or novel inventions</td>
<td>Snake repellant identification Inhibitors of integrase in HIV Hybrid vehicle control methods</td>
</tr>
<tr>
<td>Organizational</td>
<td>Advances in the way government is organized</td>
<td>SSA and DHS Outsourcing Crowdsourcing citizen science</td>
</tr>
<tr>
<td>Regulatory</td>
<td>Changes in the process of making regulations, enforcement, and adjudication</td>
<td>Negotiated rulemaking E-rulemaking</td>
</tr>
<tr>
<td>Policy</td>
<td>New types of regulatory policies to achieve social welfare or desired policy objectives</td>
<td>Cap and Trade Spectrum Auctions</td>
</tr>
<tr>
<td>Innovation Type</td>
<td>Author/Agency</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>Medicaid Prescription Drug Dispute Resolution</td>
<td>Health Care Finance Administration</td>
<td></td>
</tr>
<tr>
<td>Internet Rulemaking for Organic Food Standards</td>
<td>Department of Agriculture</td>
<td></td>
</tr>
<tr>
<td>PulseNet</td>
<td>Centers for Disease Control</td>
<td></td>
</tr>
<tr>
<td>Continuum of Care</td>
<td>Housing and Urban Development</td>
<td></td>
</tr>
<tr>
<td>Best Manufacturing Practices Program</td>
<td>Department of Defense</td>
<td></td>
</tr>
<tr>
<td>Fast-Track Product Recall Program</td>
<td>Consumer Product Safety Commission</td>
<td></td>
</tr>
<tr>
<td>Northern New Mexico Collaborative Stewardship</td>
<td>U.S. Forest Service</td>
<td></td>
</tr>
<tr>
<td>Secure Electronic Network for Travelers Rapid Inspection</td>
<td>Inter-Agency Task Force</td>
<td></td>
</tr>
<tr>
<td>Control of Asphalt Fume during Paving</td>
<td>Department of Transportation</td>
<td></td>
</tr>
<tr>
<td>National New Hire Reporting</td>
<td>Department of Health and Human Services</td>
<td></td>
</tr>
<tr>
<td>Reform of the U.S. Drug Approval Process</td>
<td>Food and Drug Administration</td>
<td></td>
</tr>
<tr>
<td>Disarming the Criminal</td>
<td>Bureau of Alcohol, Tobacco, and Firearms</td>
<td></td>
</tr>
<tr>
<td>33/50 Program</td>
<td>Environmental Protection Agency</td>
<td></td>
</tr>
<tr>
<td>TeleFile</td>
<td>Internal Revenue Service</td>
<td></td>
</tr>
<tr>
<td>Consequence Assessment Tool Set and Operations Concept</td>
<td>Federal Emergency Management Agency</td>
<td></td>
</tr>
<tr>
<td>No Sweat: Eradicating Sweatshops</td>
<td>Department of Labor</td>
<td></td>
</tr>
<tr>
<td>U.S. Export Assistance Centers</td>
<td>Department of Commerce</td>
<td></td>
</tr>
<tr>
<td>Evaluating Oral Proposals in Major Government Procurements</td>
<td>Federal Aviation Administration</td>
<td></td>
</tr>
<tr>
<td>Ozone Depleting Chemical Elimination</td>
<td>U.S. Air Force</td>
<td></td>
</tr>
<tr>
<td>Early Warning Program</td>
<td>Pension Benefit Guaranty Corporation</td>
<td></td>
</tr>
<tr>
<td>Multimedia Medical Language Translator</td>
<td>U.S. Navy</td>
<td></td>
</tr>
</tbody>
</table>

Source: Innovation in Government Awards; Ash Center at the Kennedy School, Harvard
# Innovation in the Federal Government

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Concept</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological</td>
<td>Technically or technologically new or novel inventions</td>
<td>Snake repellant identification Inhibitors of integrase in HIV Hybrid vehicle control methods</td>
</tr>
<tr>
<td>Organizational</td>
<td>Advances in the way government is organized</td>
<td>SSA and DHS Outsourcing Crowdsourcing citizen science</td>
</tr>
<tr>
<td>Regulatory</td>
<td>Changes in the process of making regulations</td>
<td>Negotiated rulemaking E-rulemaking</td>
</tr>
<tr>
<td>Policy</td>
<td>New types of regulatory policies to achieve social welfare or desired policy outcomes</td>
<td>Cap and Trade Spectrum Auctions</td>
</tr>
</tbody>
</table>
Federal Spending on R&D


Source: Office of Management and Budget, Historical Table 9.7
Federal Spending on R&D


Source: Office of Management and Budget, Historical Table 9.8
Federal Spending on R&D


R&D Inputs by Agency

Figure 4: R&D in FY 2017
budget authority in billions of dollars

<table>
<thead>
<tr>
<th>Agency</th>
<th>Budget Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOD</td>
<td>$51.1</td>
</tr>
<tr>
<td>DOE</td>
<td>$15.3</td>
</tr>
<tr>
<td>HHS</td>
<td>$34.0</td>
</tr>
<tr>
<td>NASA</td>
<td>$10.7</td>
</tr>
<tr>
<td>USDA</td>
<td>$2.6</td>
</tr>
<tr>
<td>Commerce</td>
<td>$1.8</td>
</tr>
<tr>
<td>NSF</td>
<td>$5.9</td>
</tr>
<tr>
<td>Other</td>
<td>$6.0</td>
</tr>
</tbody>
</table>

Estimates based on agency and OMB data. R&D includes conduct of R&D and facilities. © 2018 AAAS

Source: AAAS 2019, Federal R&D Budget Trends: A Short Summary
Positions Engaged in R&D in the Federal Government


R&D-Focused Positions

R&D-Adjacent Positions

R&D-focused positions are those classified as "Research," "Development," or "Testing & Evaluation".

R&D-adjacent positions are those classified as "R&D Grant Administration," "Data Analysis," "Scientific and Technical Information," or "Management (of Science)".

Agency Category
- Non-DOD Personnel
- DOD Personnel
Scientists in the Federal Government


DOD Personnel

Non-DOD Personnel

Source: OPM Personnel Records
Scientists Outside the DOD

Only non-DOD personnel

Source: OPM Personnel Records
Scientists Differ Between the DOD and the Rest of Government

Federal Personnel by Area of Science as Percent of Annual Total, 1980-2014

Note: DOD = Department of Defense
Source: Statistical Analysis of OPM CDPF-EHRI
Federal Government Patent Output

Annual US Patents with Government Affiliation, 1975-2013

Data on government affiliation type from PatentsView.org
Federal Government Patent Output

US Patents Assigned to Select Companies and US Federal Government, 1975-2013

- Assignee:
  - DuPont
  - Google
  - IBM
  - Texas Instruments
  - US Federal Government
Federal Government Patent Output

Patents Assigned to US Federal Agencies, 1975-2013
Data from PatentsView.org

Agency

Total Patents

DOD  Energy  NASA  HHS  USDA  Interior  Commerce  All Other Non-DOD  VA  NSA
Federal Government Patent Output

Patents with Government Interest Statements by Federal Agency, 1975-2013

Data from PatentsView.org

<table>
<thead>
<tr>
<th>Agency</th>
<th>Total Patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHS</td>
<td>35000</td>
</tr>
<tr>
<td>DOD</td>
<td>30000</td>
</tr>
<tr>
<td>Energy</td>
<td>25000</td>
</tr>
<tr>
<td>All Other Non-DOD</td>
<td>20000</td>
</tr>
<tr>
<td>NSF</td>
<td>15000</td>
</tr>
<tr>
<td>NASA</td>
<td>5000</td>
</tr>
<tr>
<td>Commerce</td>
<td>2000</td>
</tr>
<tr>
<td>USDA</td>
<td>1000</td>
</tr>
<tr>
<td>SBA</td>
<td>500</td>
</tr>
<tr>
<td>DOT</td>
<td>100</td>
</tr>
</tbody>
</table>
Government Patent Novelty

Originality based on breadth of patent classes cited in focal patent (Trajtenberg et al. 1997).
Government Patent Novelty

Originality based on breath of patent classes cited in focal patent (Trajtenberg et al. 1997).

Assignee Type
- - US Companies
US Federal Government
Government Patent Novelty

Originality based on breadth of patent classes cited in focal patent (Trajtenberg et al. 1997).
Government Patents Generality

Generality based on breadth of patent classes citing focal patent (Trajtenberg et al. 1997).
Government Patents Generality

Generality based on breadth of patent classes citing focal patent (Trajtenberg et al. 1997).

Assignee Type
- - US Companies
------- US Federal Government
Government Patents Generality

Generality based on breadth of patent classes citing focal patent (Trajtenberg et al. 1997).

Assignee Type
- US Companies
- US Federal Government
Government Patent Quality

Patent citation records from NBER Patent Data Project.

Assignee Type
- - US Companies
--- US Federal Government
Government Patent Quality

Patent citation records from NBER Patent Data Project.

Assignee Type
- - US Companies
-- US Federal Government
Government Patent Quality

Patent citation records from NBER Patent Data Project.
Government Patent Quality

Federally- versus Privately-Assigned Patents’ Median Citations by CPC Subsection, 1975-2003
Gray lines represent 118 CPC patent subsections. Lines above dashed horizontal line indicates median government patent cited more than privately-assigned median patent in the subsection.

Annual difference calculated by subtracting private patent median from government patent median within each CPC subsection. Lines only plotted in years when both government and private patents are cited in the subsection.
Government Patent Share by Technology

Top five groups highlighted with highest weighted average percent; gray lines represent all 631 CPC groups

Denominator is combined patents assigned to US companies and federal government. Annual average weighted by number of federally-assigned patents.

Note: Percent Federally Assigned weighted by number of patents in CPC Group
Source: PatentsView.org
Diffusion Across Time: Example of Machine Learning

Machine Learning in Google NGrams & Federal Documents, 1940-2019

Year


NGram Prevalence (10e-7)

Federal Document Mentions

Source: Google Books Ngram Viewer; Govinfo.gov
Diffusion Across Agencies: Machine Learning

Science Agencies
NIH
NOAA
NSF
DOE
NIH
CDC

Technical Agencies
NLibMed
OSTP
FCC
NTIS
FDA
DIB
ASAC

Non-Science Agencies
Bureau of Reclamation (BRec)
CFPB
SEC
ISPB
CMS

Note: Acronyms are agencies; year is year that "machine learning" first appears in the Federal Register for a given agency; arrows indicate sequence of appearance. Source: FederalRegister.gov
Diffusion Across Agencies: Touchtone Data Entry

Technical Agencies
Census
BLS
IRS


Note: Acronyms are agencies; year is year that “machine learning” first appears in the Federal Register for a given agency; arrows indicate sequence of appearance. Source: FederalRegister.gov
Government Innovation: Summary

• Classification of Innovation in the Government
• Inputs
  • Scientists
  • Budgets
• Outputs: Government-Assigned Patents (Hard Science/Engineering)
• Diffusion of Innovation
• To understand innovation in the federal government, measuring the scope and impact of non-technological innovations is important