

# Innovation in the U.S. Federal Government

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Duke University

# 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

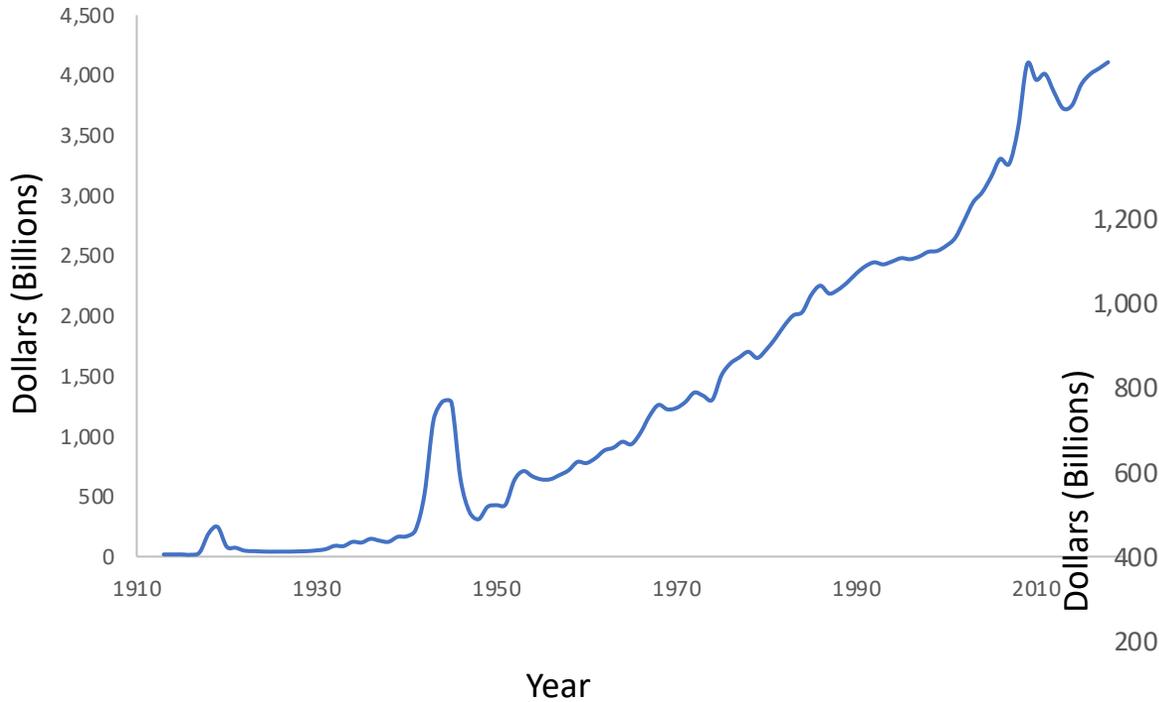
- Government-Assigned Patent Output (Hard Science/Engineering)
  - The quantity of government-assigned patents looks like a large firm (TI, DuPont)
  - The areas in which the government patents
    - Biggest areas: Medical Science; Biochemistry; Measuring and Testing; Calculating and Counting
    - Biggest 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

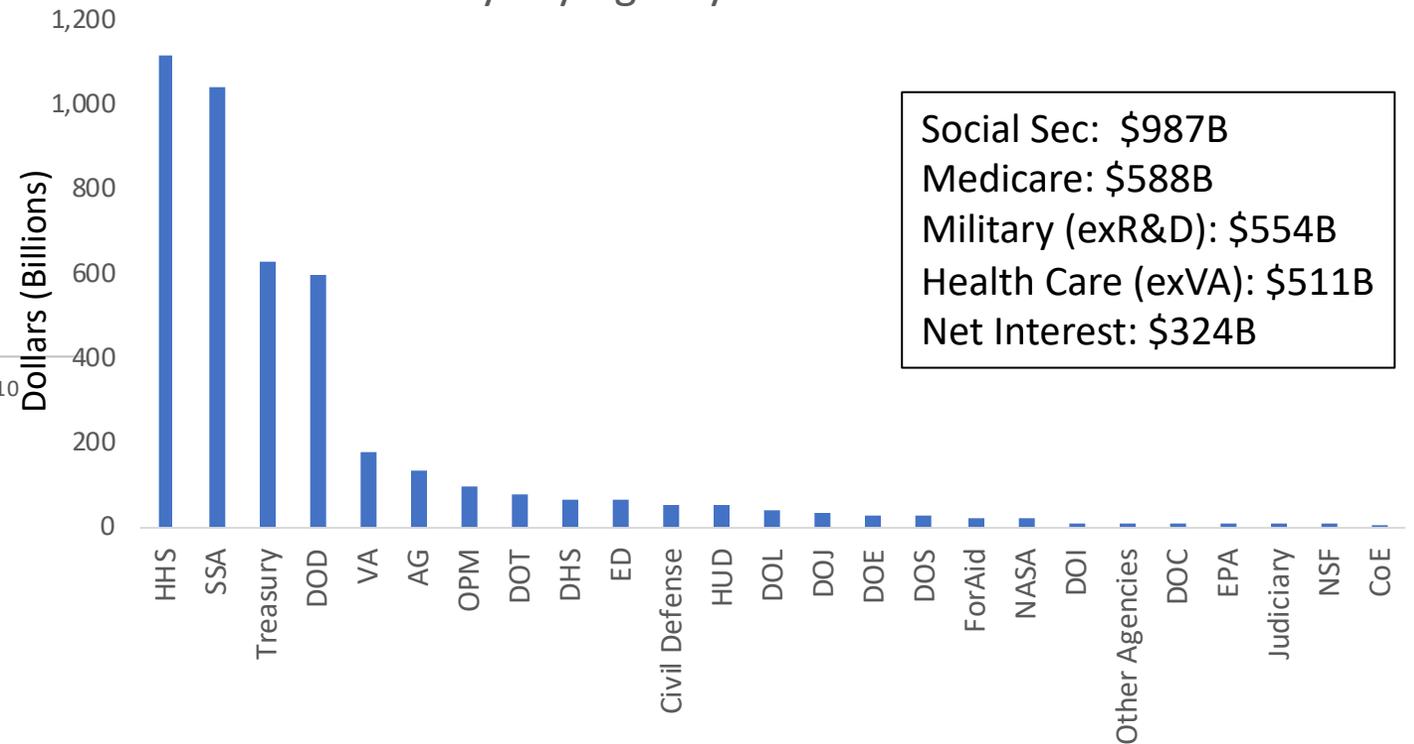
- Taxonomy of Government Innovation: Hartley (2005); Hartley et al (2013); Chen et al (2019); de Vries et al (2016); Bommert (2010); Edquist (2012);
- Methods for Measuring Government Innovation and Patents: Arundel et al (2019); Jaffe et al (1993); Jaffe and Trajtenberg (1996); Trajtenberg et al (1997); Valero and Van Reenen (2019)
- External Government R&D Spending Programs and Outputs: Bloom et al (2019)
- 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)



Outlays by Agency 2018



# Federal Government Employees

## 2018 FTE Employees

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

# Federal Government Employees

GS Grade Distribution, 1988 vs. 2011

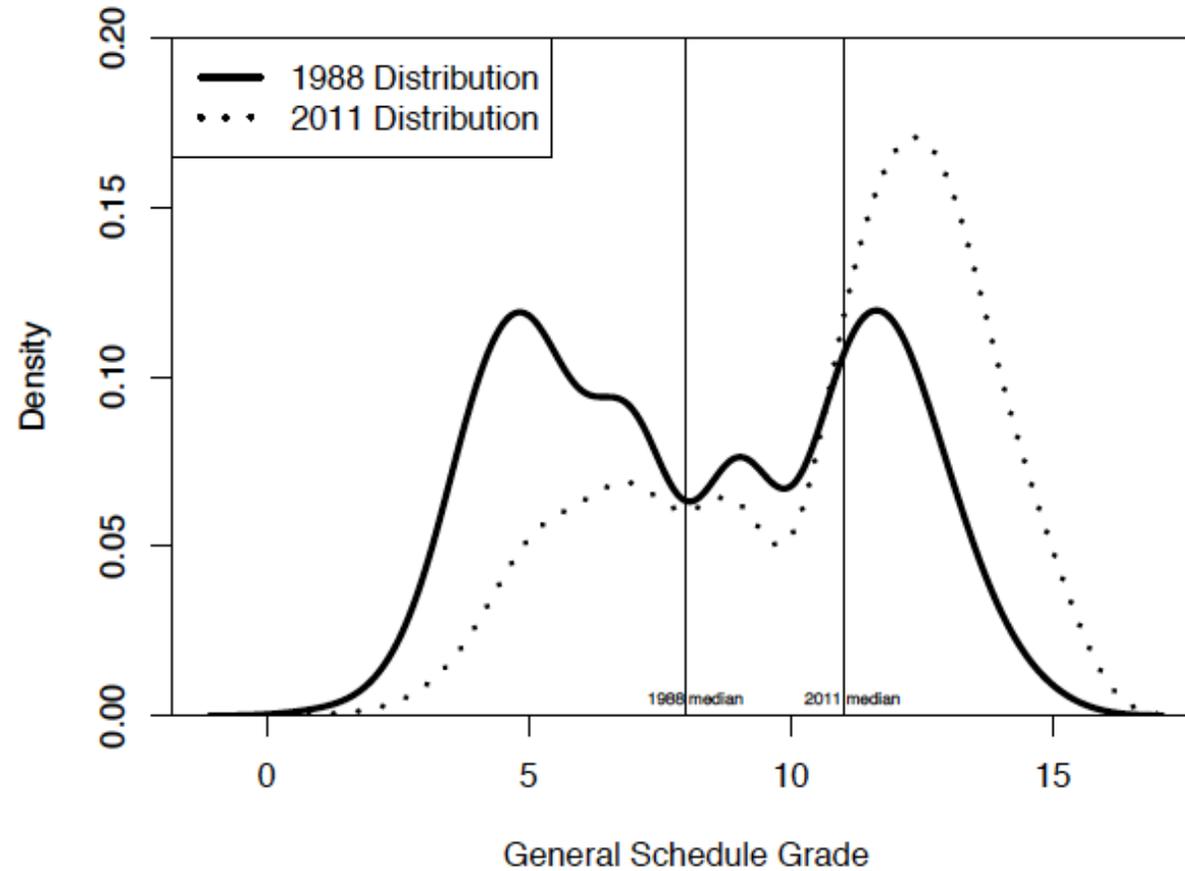


Figure 2: Distribution of GS Grades Over Time.

# Federal Government Employees

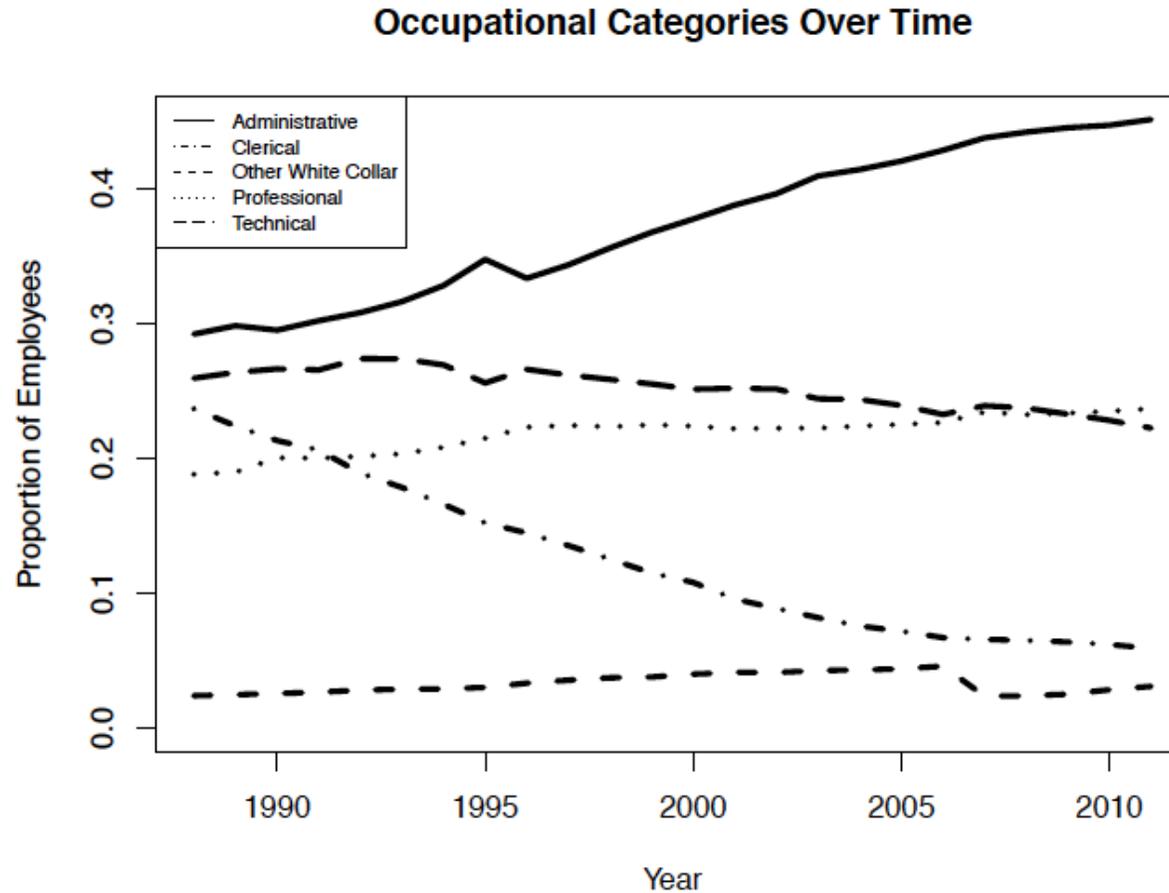


Figure 7: Changing Nature of Federal Work.

# Classification of Innovation in the Federal Government

Innovation	Concept	Example
Technological	Technically or technologically new or novel inventions	Snake repellent identification Inhibitors of integrase in HIV Hybrid vehicle control methods
Organizational	Advances in the way government is organized	SSA and DHS Outsourcing Crowdsourcing citizen science
Regulatory	Changes in the process of making regulations, enforcement, and adjudication	Negotiated rulemaking E-rulemaking
Policy	New types of regulatory policies to achieve social welfare or desired policy objectives	Cap and Trade Spectrum Auctions

# Organizational, Regulatory and Policy Types of Innovations

Medicaid Prescription Drug Dispute Resolution	Health Care Finance Administration
Internet Rulemaking for Organic Food Standards	Department of Agriculture
PulseNet	Centers for Disease Control
Continuum of Care	Housing and Urban Development
Best Manufacturing Practices Program	Department of Defense
Fast-Track Product Recall Program	Consumer Product Safety Commission
Northern New Mexico Collaborative Stewardship	U.S. Forest Service
Secure Electronic Network for Travelers Rapid Inspection	Inter-Agency Task Force
Control of Asphalt Fume during Paving	Department of Transportation
National New Hire Reporting	Department of Health and Human Services
Reform of the U.S. Drug Approval Process	Food and Drug Administration
Disarming the Criminal	Bureau of Alcohol, Tobacco, and Firearms
33/50 Program	Environmental Protection Agency
TeleFile	Internal Revenue Service
Consequence Assessment Tool Set and Operations Concept	Federal Emergency Management Agency
No Sweat: Eradicating Sweatshops	Department of Labor
U.S. Export Assistance Centers	Department of Commerce
Evaluating Oral Proposals in Major Government Procurements	Federal Aviation Administration
Ozone Depleting Chemical Elimination	U.S. Air Force
Early Warning Program	Pension Benefit Guaranty Corporation
Multimedia Medical Language Translator	U.S. Navy

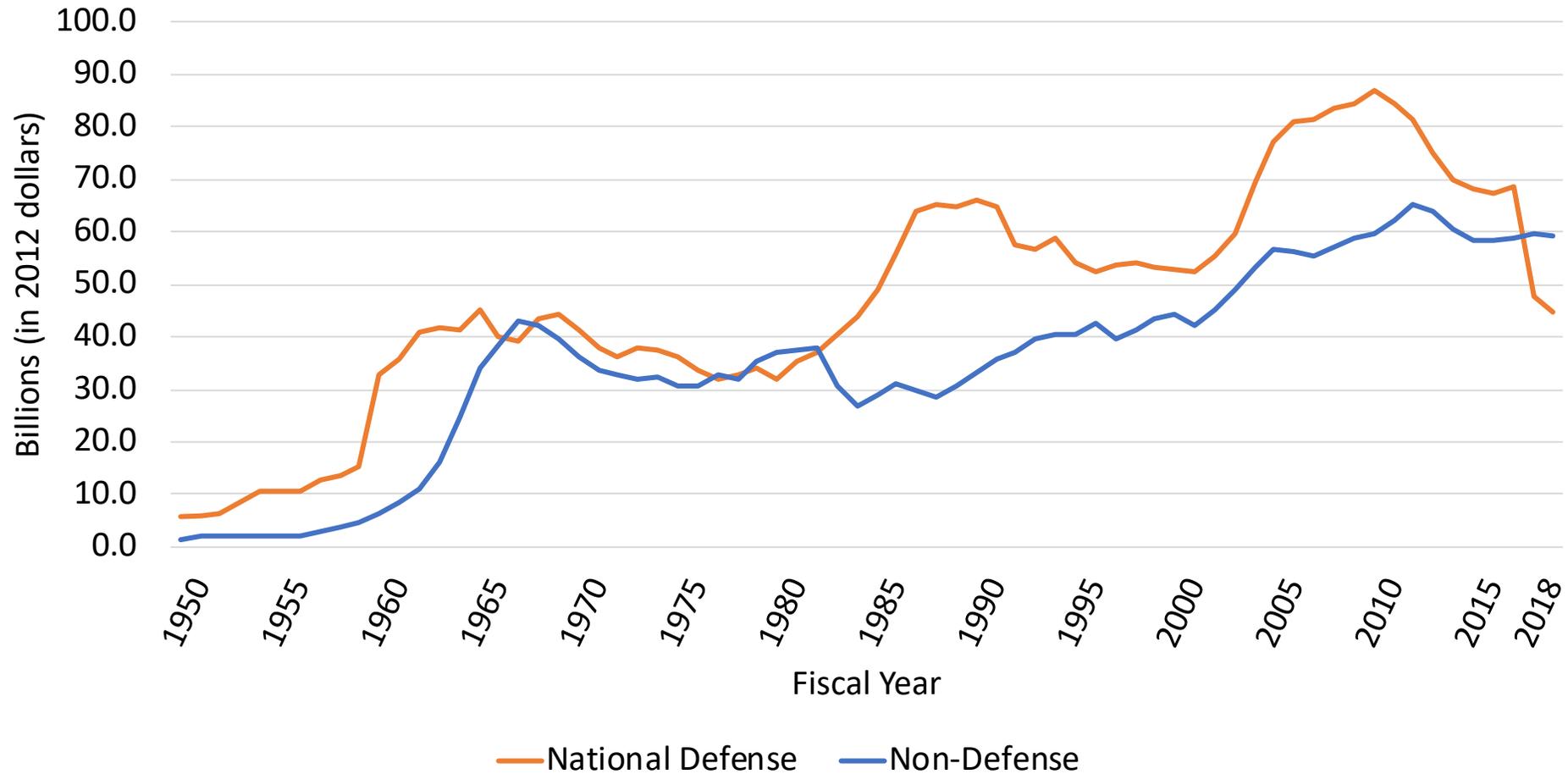
Source: Innovation in Government Awards;  
Ash Center at the Kennedy School, Harvard

# Innovation in the Federal Government

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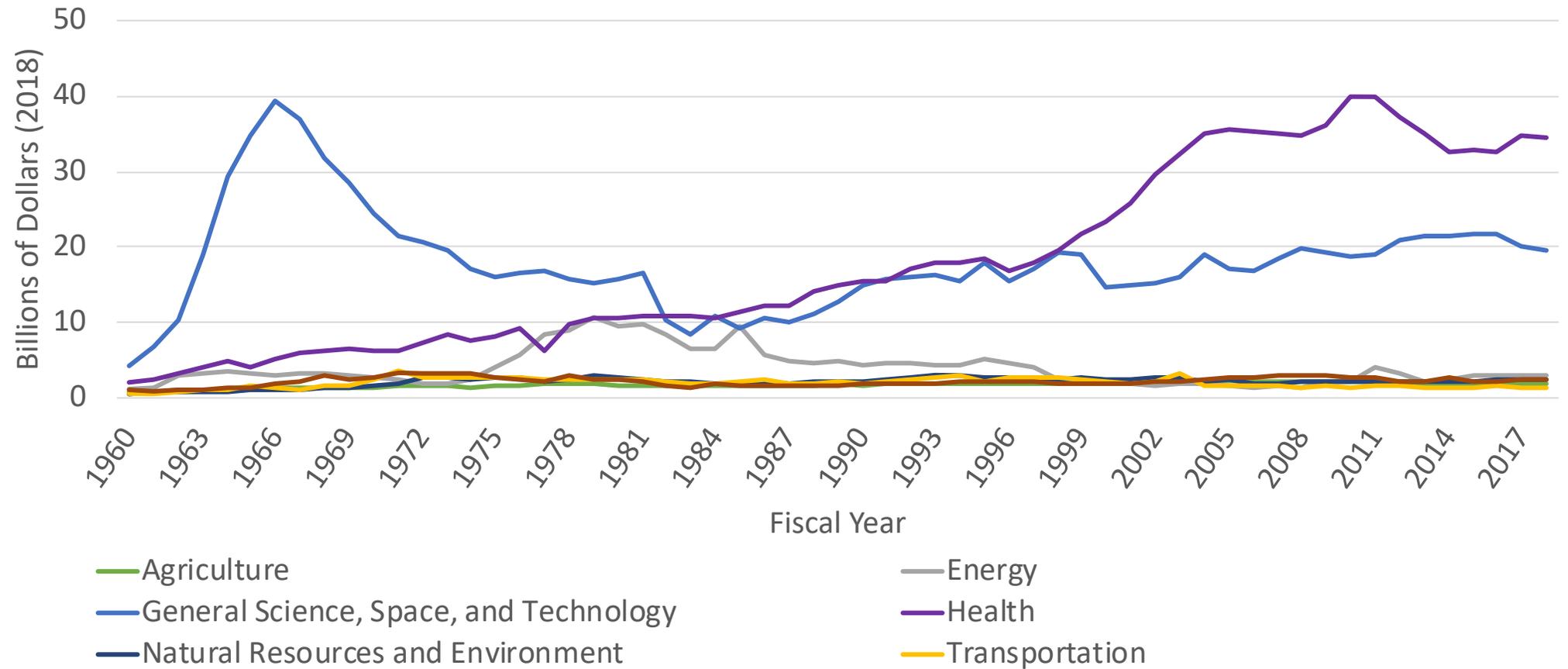
# Federal Spending on R&D

Constant (2012) Federal Outlays for R&D, 1949-2018



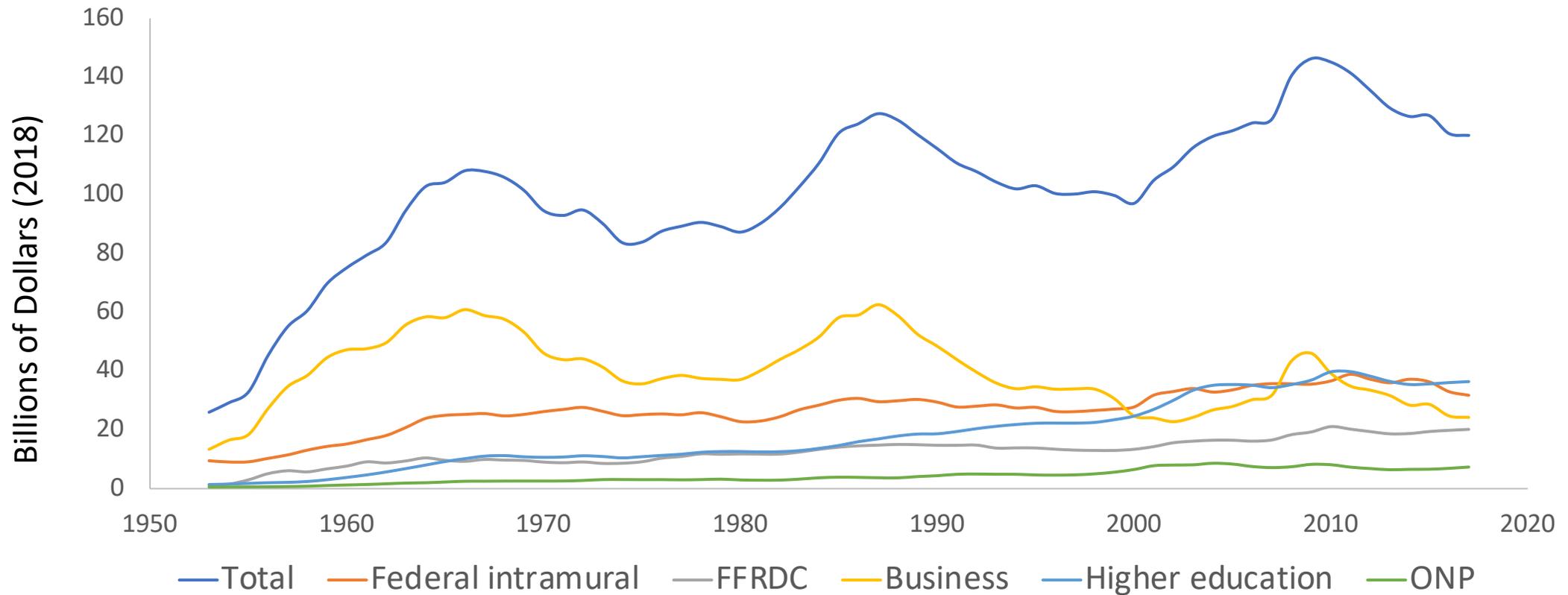
# Federal Spending on R&D

Federal Non-Defense R&D Outlays by Area in Constant (2018) Dollars, 1960-2018

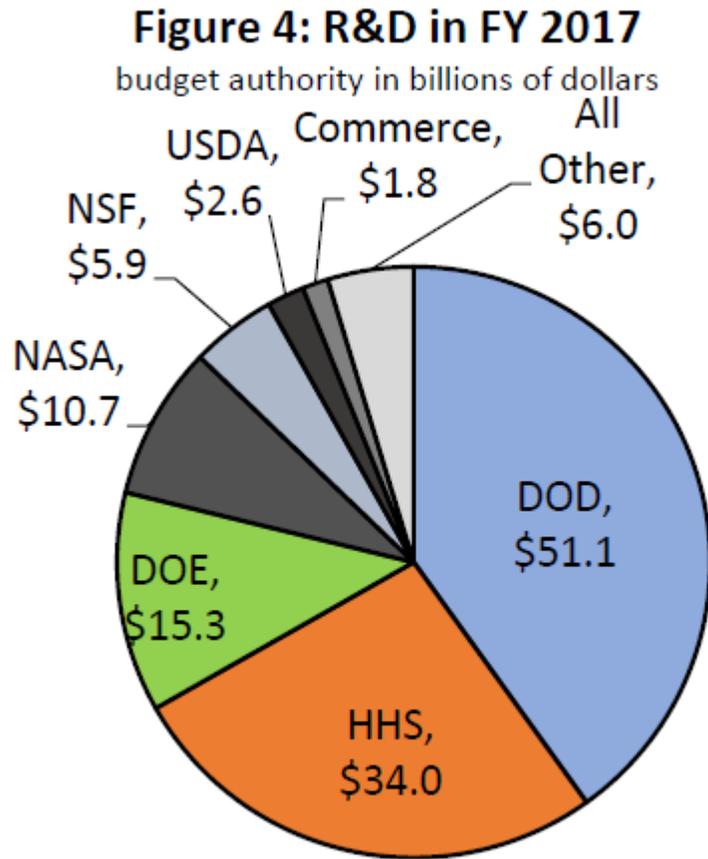


# Federal Spending on R&D

Performers of Federally Funded R&D in Billions (2018) Dollars, 1953-2017



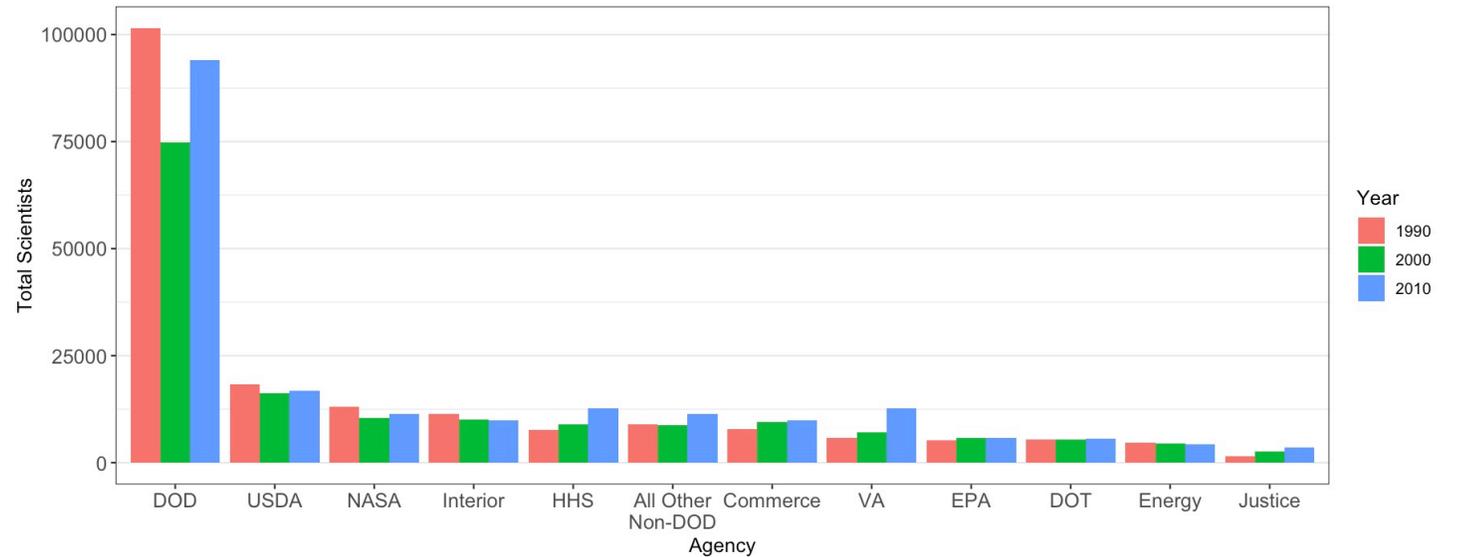
# R&D Inputs by Agency



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

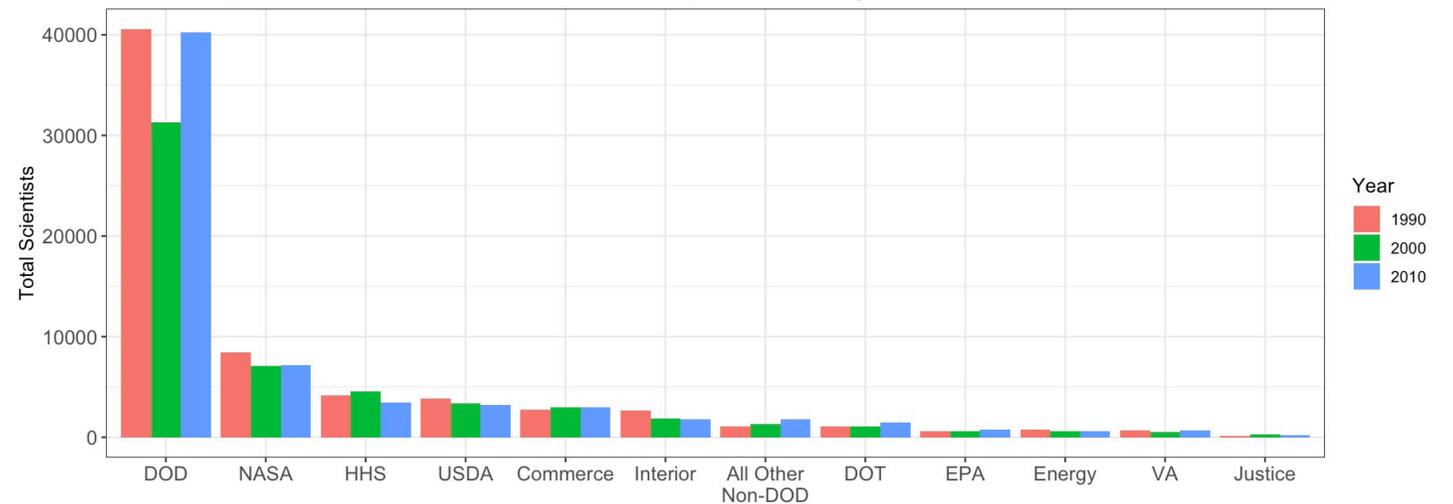
Source: AAAS 2019, Federal R&D Budget Trends: A Short Summary

Scientist Employment by Agency in 1990, 2000, and 2010



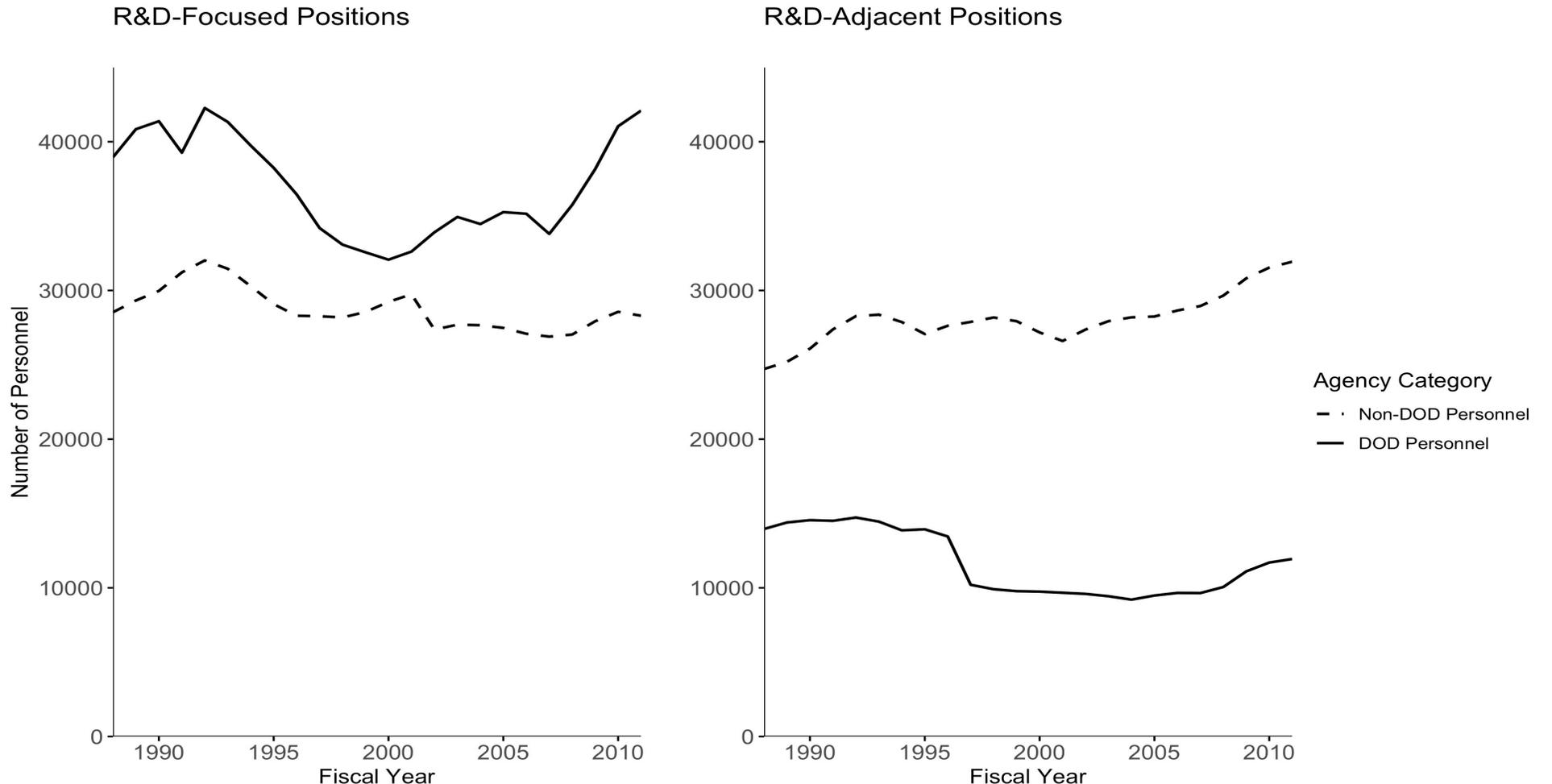
R&D-Focused Scientist Employment by Agency in 1990, 2000, and 2010

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



# Positions Engaged in R&D in the Federal Government

Federal Personnel by R&D Functional Classifications and DOD Affiliation, 1980-2014

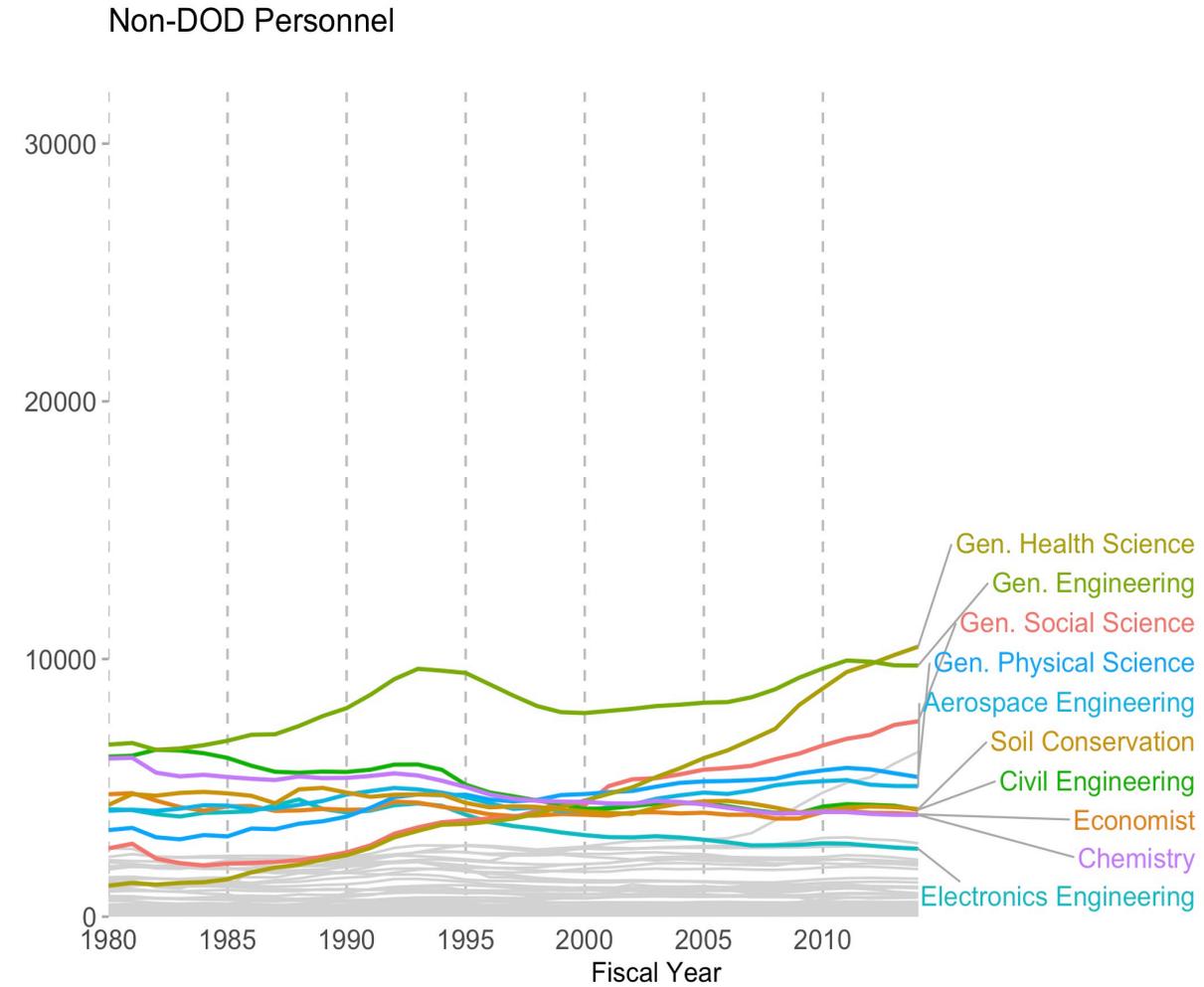
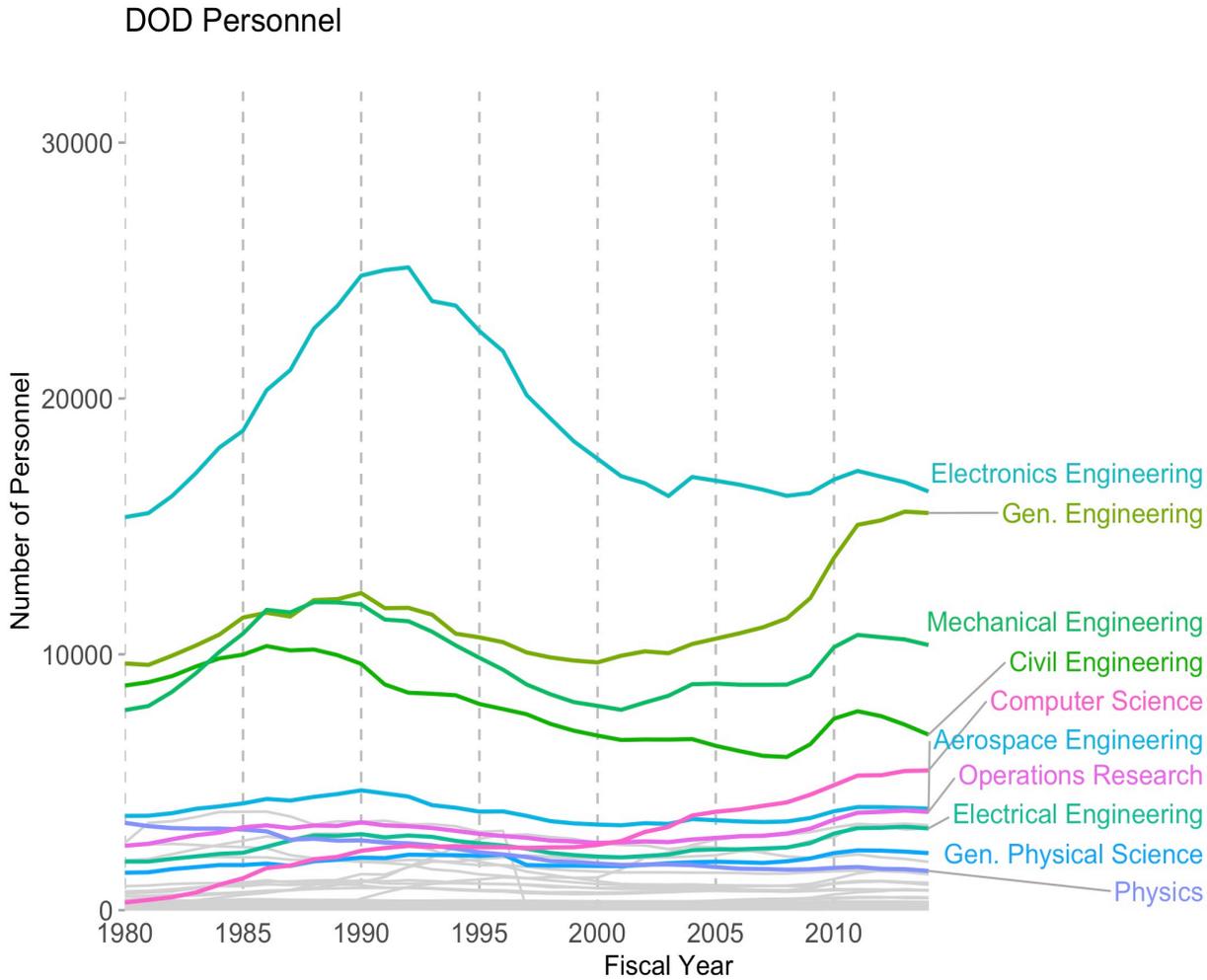


R&D-focused positions are those classified as "Research," "Development," or "Testing & Evaluation"

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

# Scientists in the Federal Government

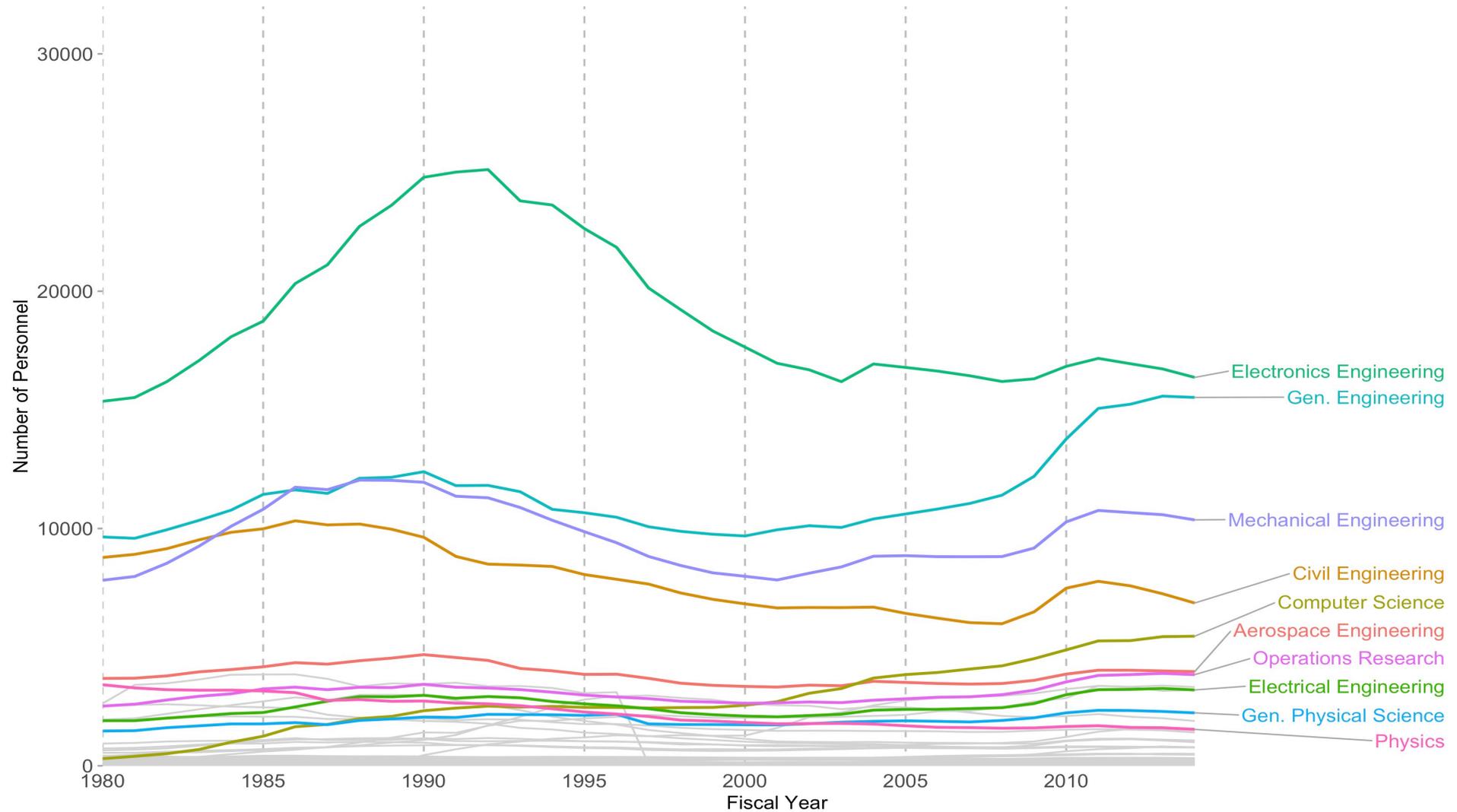
Federal Scientific Occupations with Highest Cumulative Employment, 1980-2014



Source: OPM Personnel Records

# Scientists in the DOD

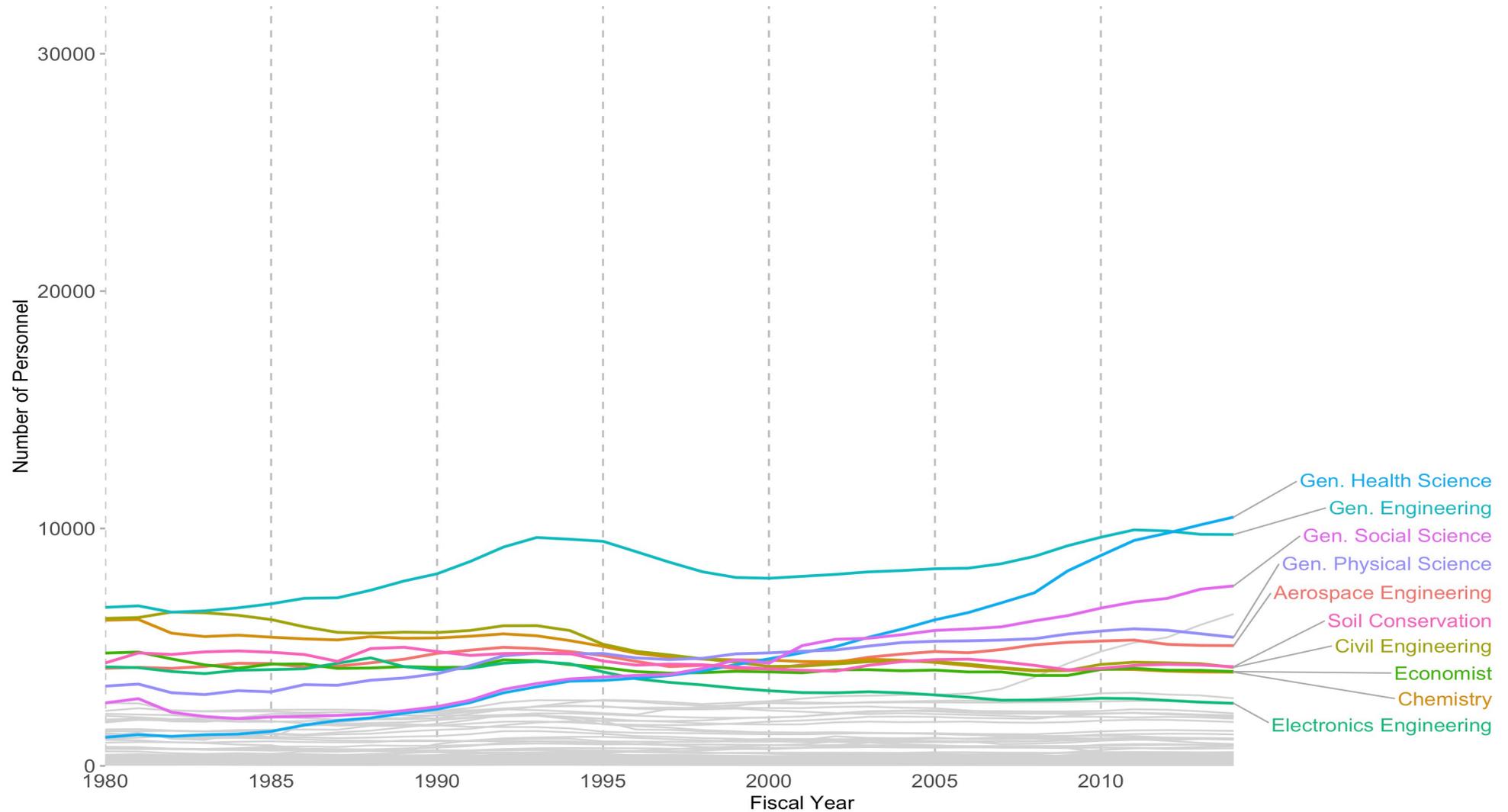
Federal Scientific Occupations with Highest Cumulative Employment, 1980-2014  
Only DOD personnel



Source: OPM Personnel Records

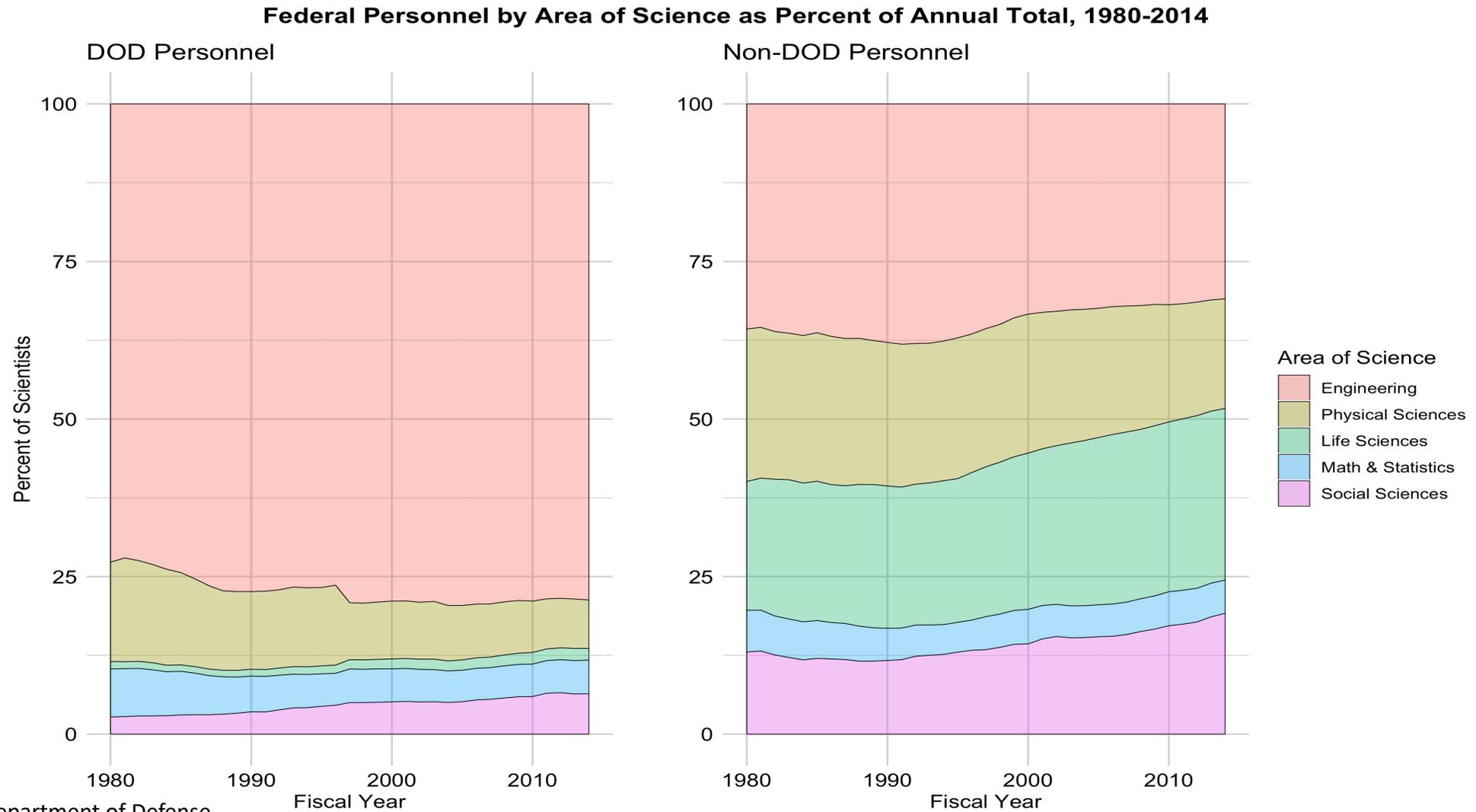
# Scientists Outside the DOD

Federal Scientific Occupations with Highest Cumulative Employment, 1980-2014  
Only non-DOD personnel



Source: OPM Personnel Records

# Scientists Differ Between the DOD and the Rest of Government

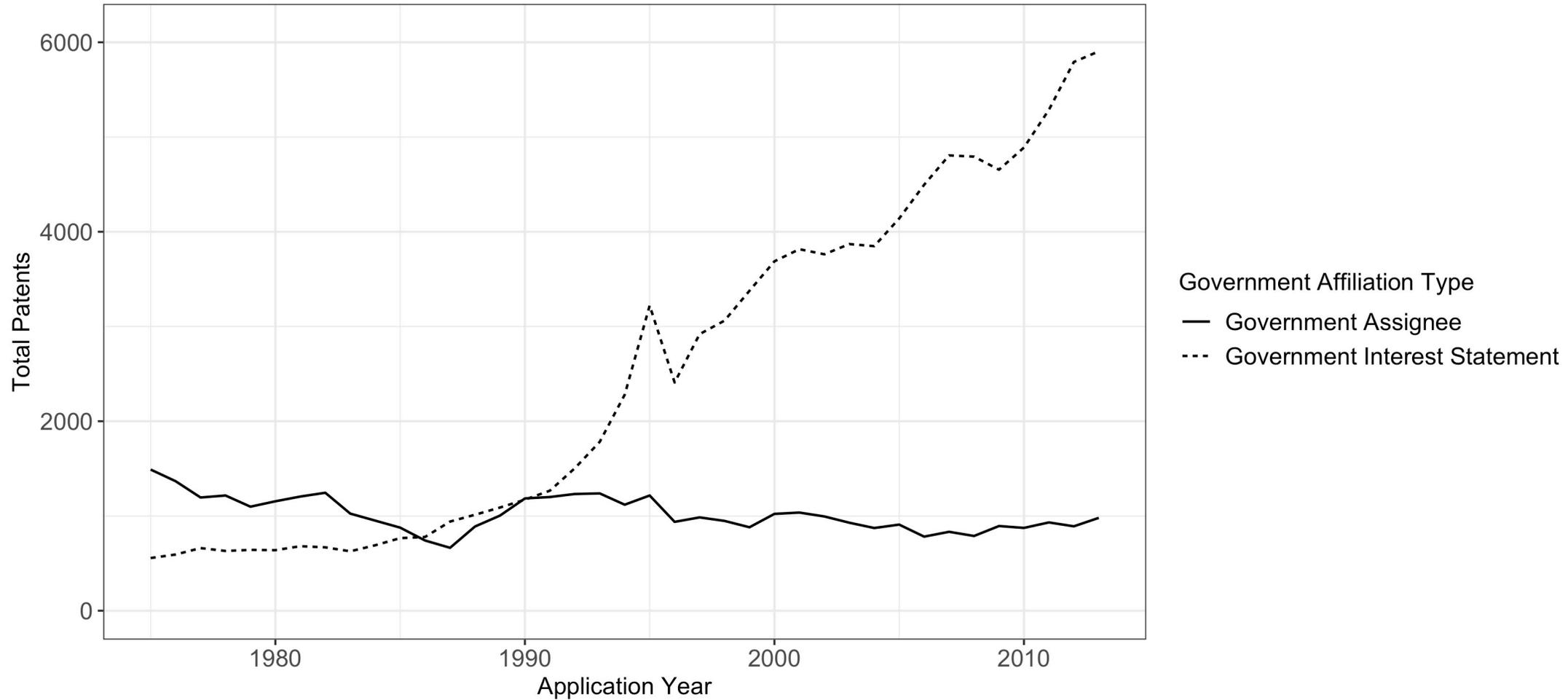


Note: DOD = Department of Defense  
Source: Statistical Analysis of OPM CDPF-EHRI

# Federal Government Patent Output

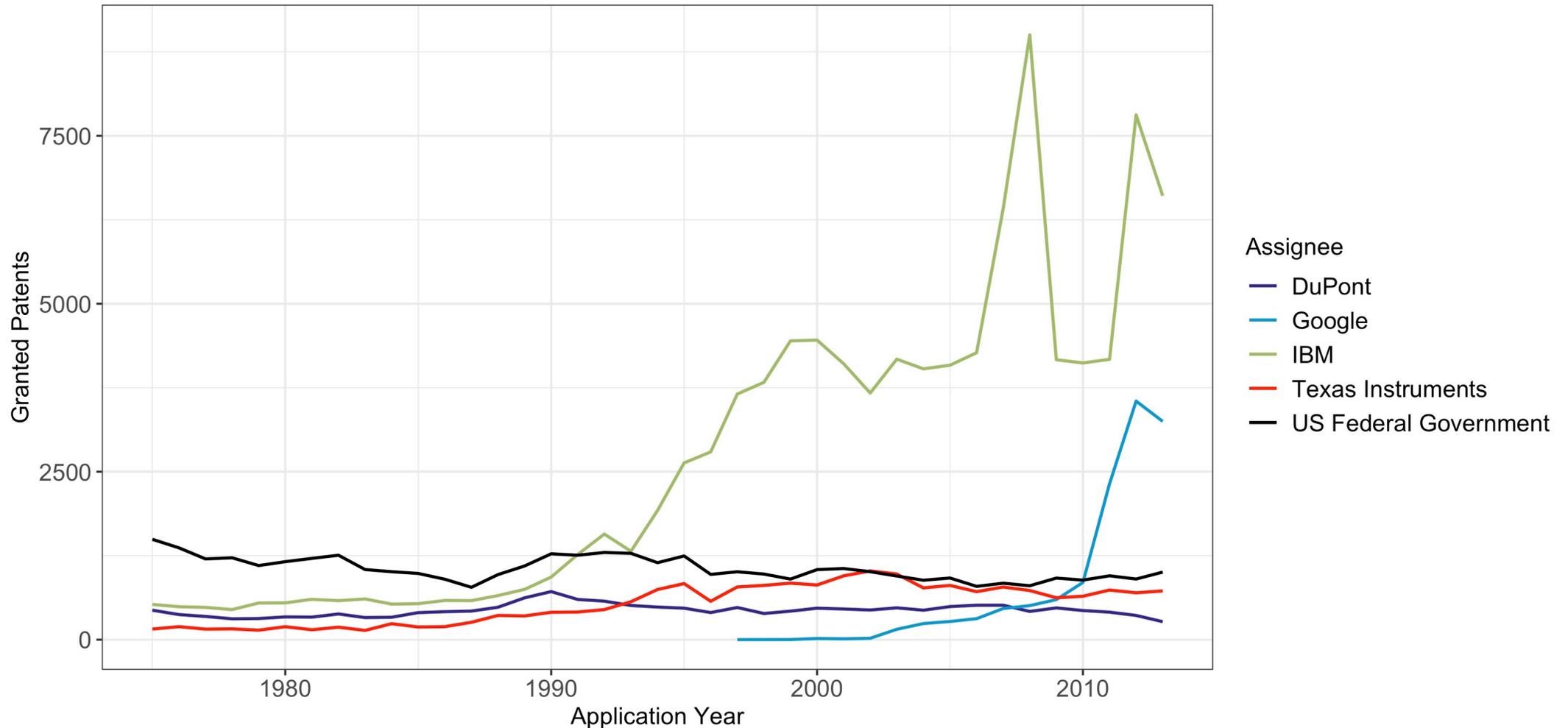
Annual US Patents with Government Affiliation, 1975-2013

Data on government affiliation type from PatentsView.org



# Federal Government Patent Output

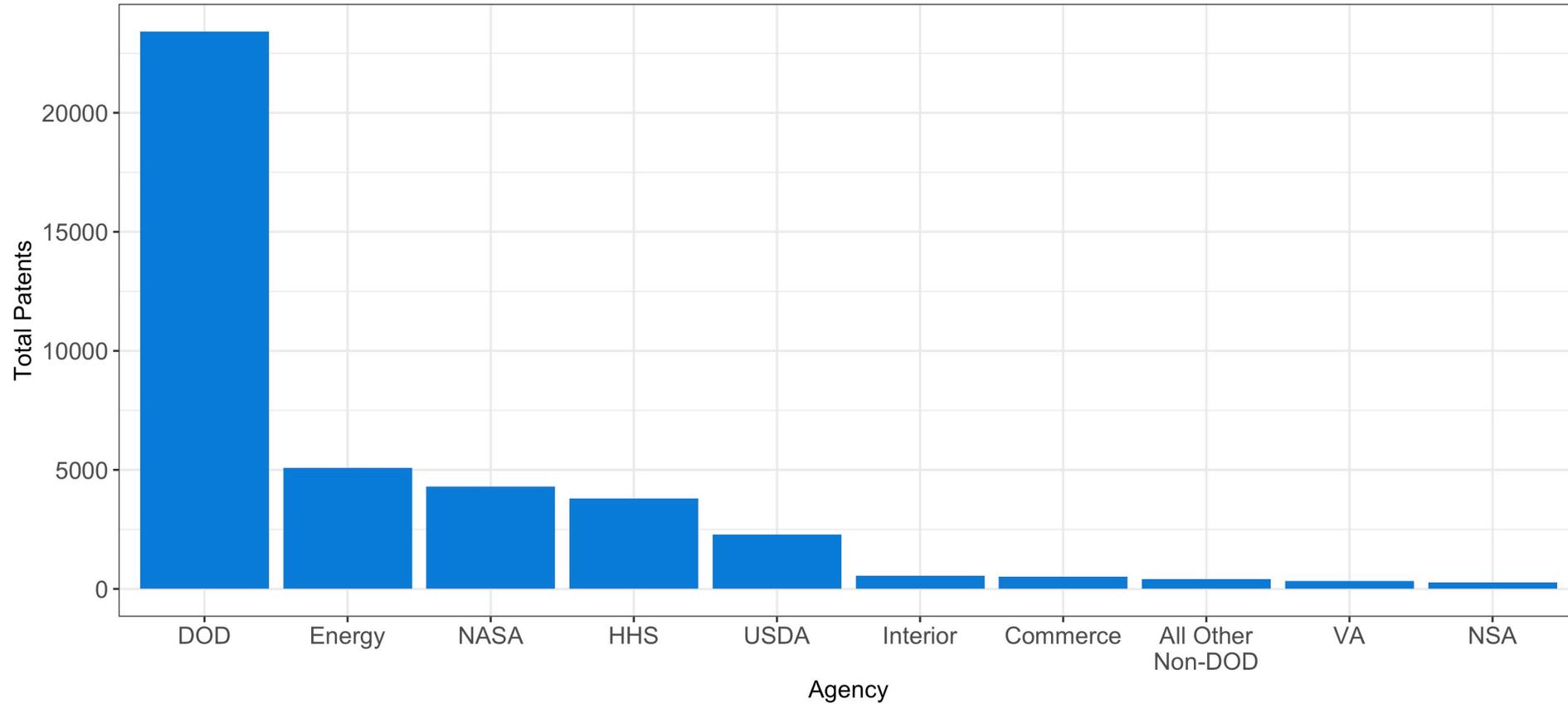
US Patents Assigned to Select Companies and US Federal Government, 1975-2013



# Federal Government Patent Output

Patents Assigned to US Federal Agencies, 1975-2013

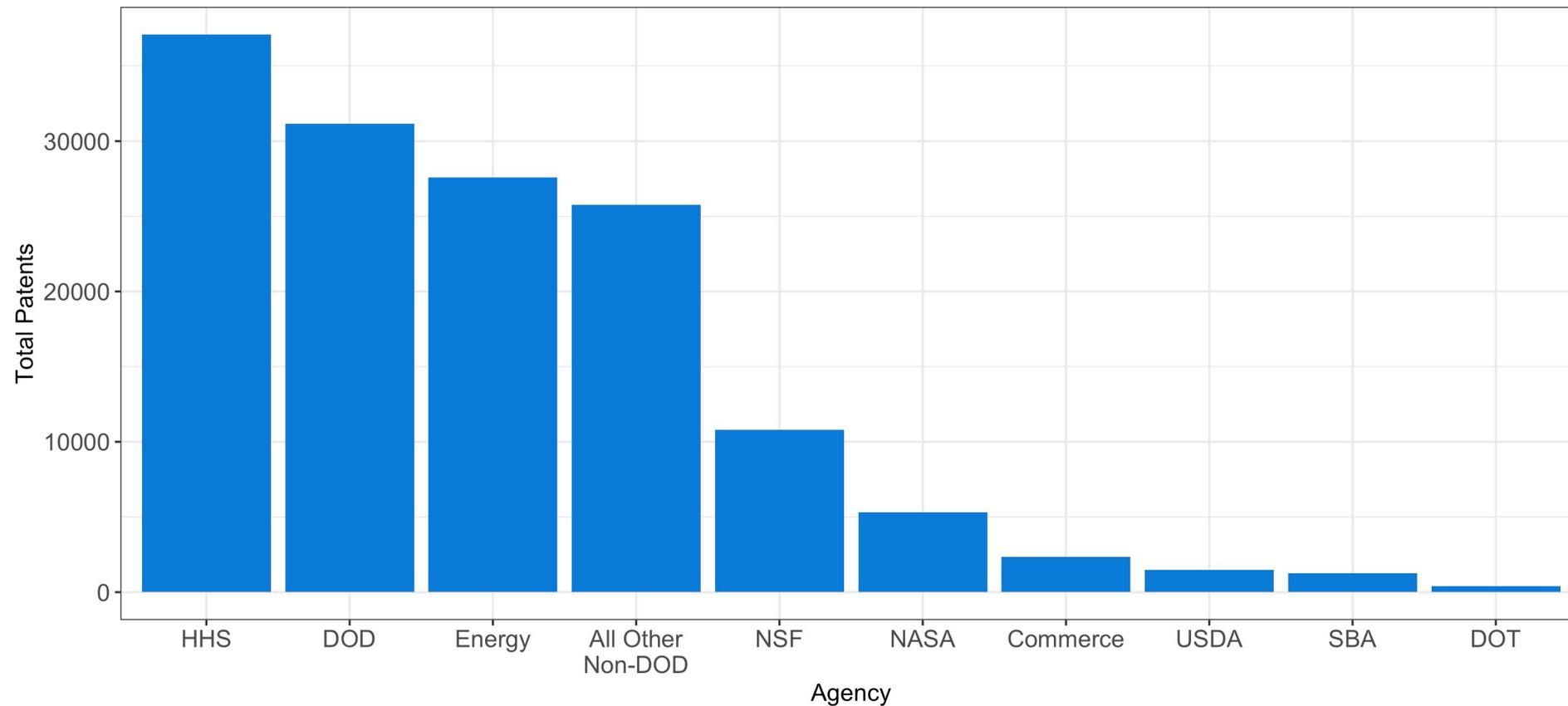
Data from PatentsView.org



# Federal Government Patent Output

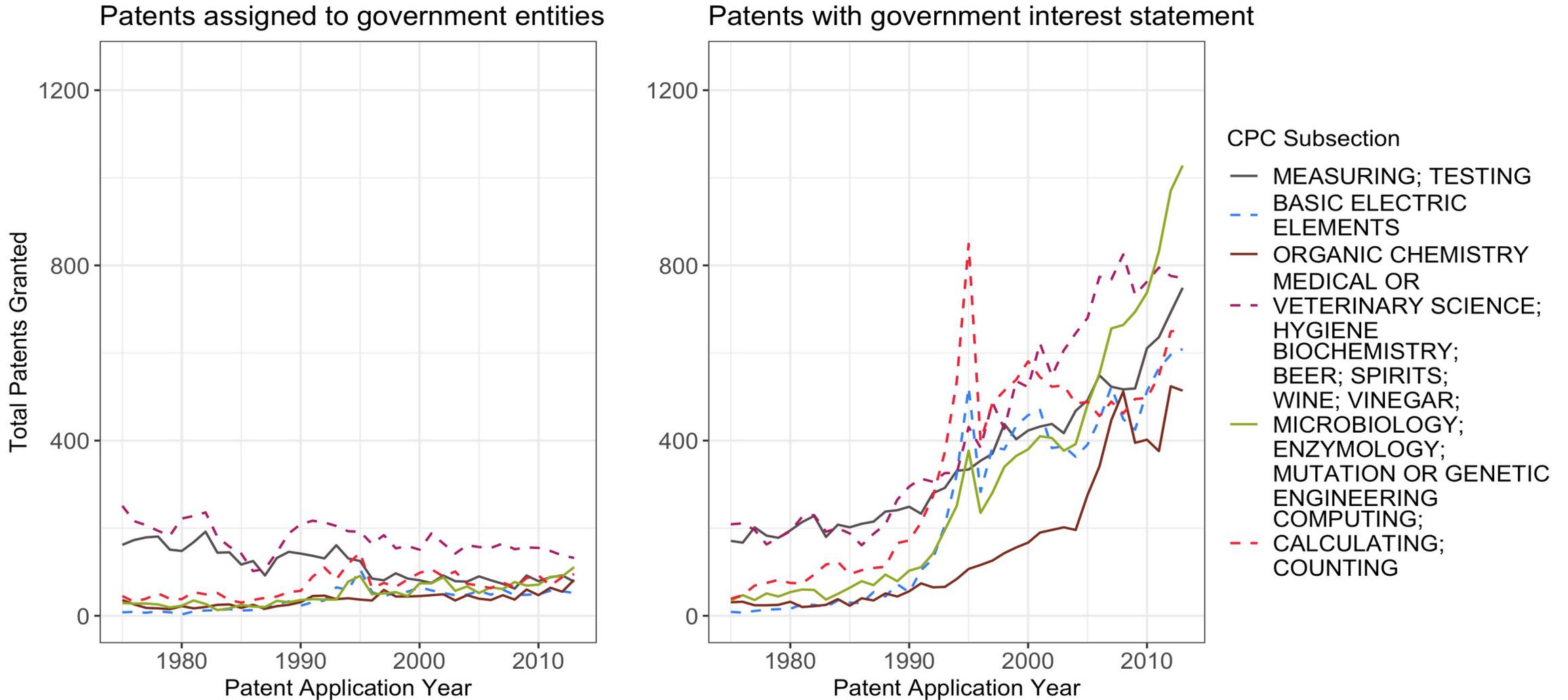
Patents with Government Interest Statements by Federal Agency, 1975-2013

Data from PatentsView.org



# Government Patent Technologies

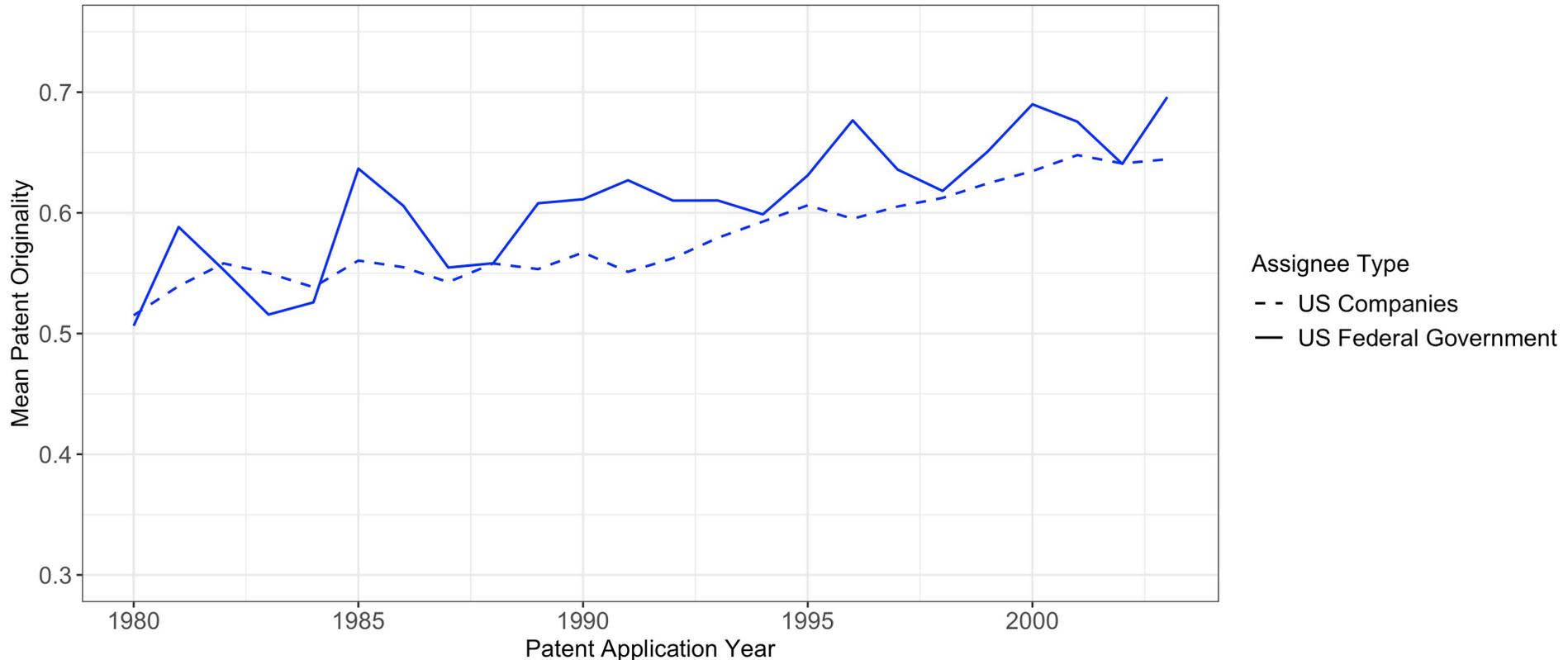
## Federally Assigned and Supported US Patents by CPC Subsection, 1975-2013



# Government Patent Novelty

Average Patent Originality in "Measuring; Testing" Patents, 1980-2003

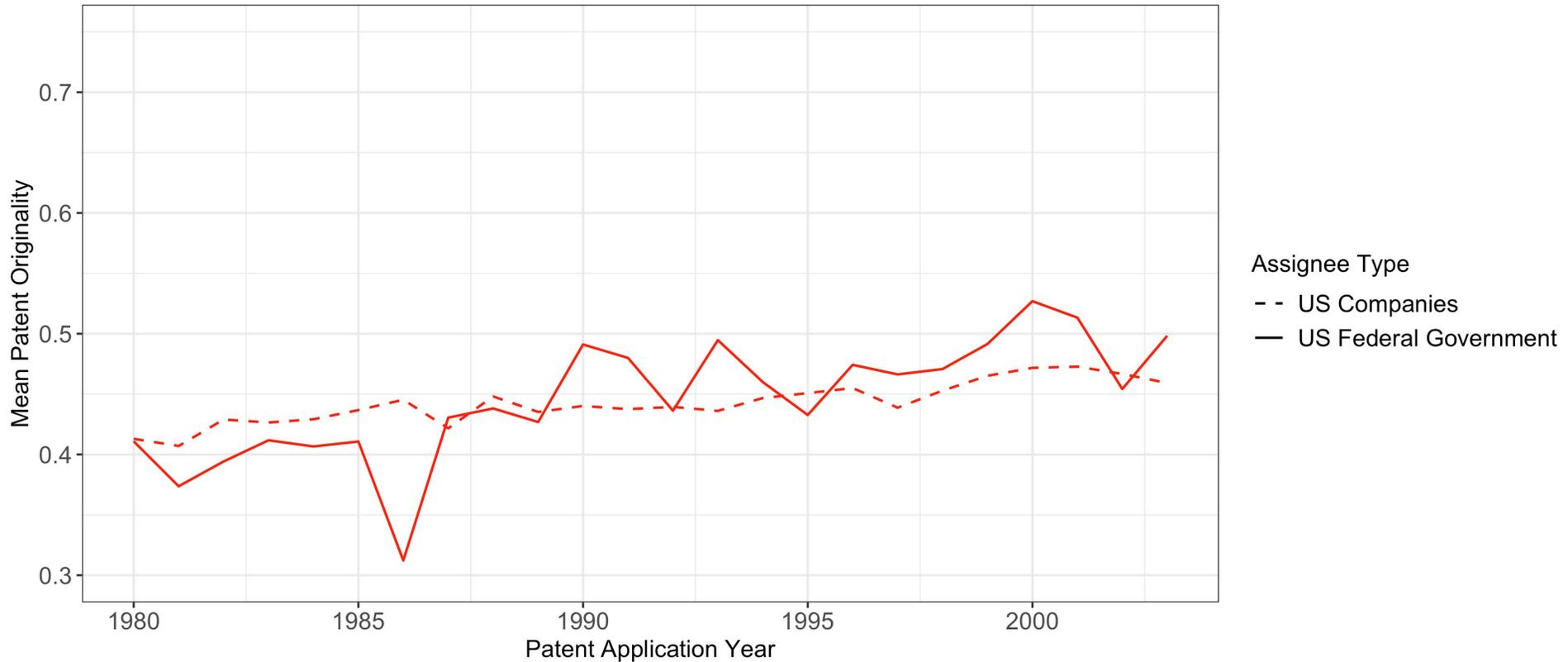
Originality based on breath of patent classes cited in focal patent (Trajtenberg et al. 1997).  
Patent originality scores from NBER Patent Data Project.



# Government Patent Novelty

Average Patent Originality in "Basic Electric Elements" Patents, 1980-2003

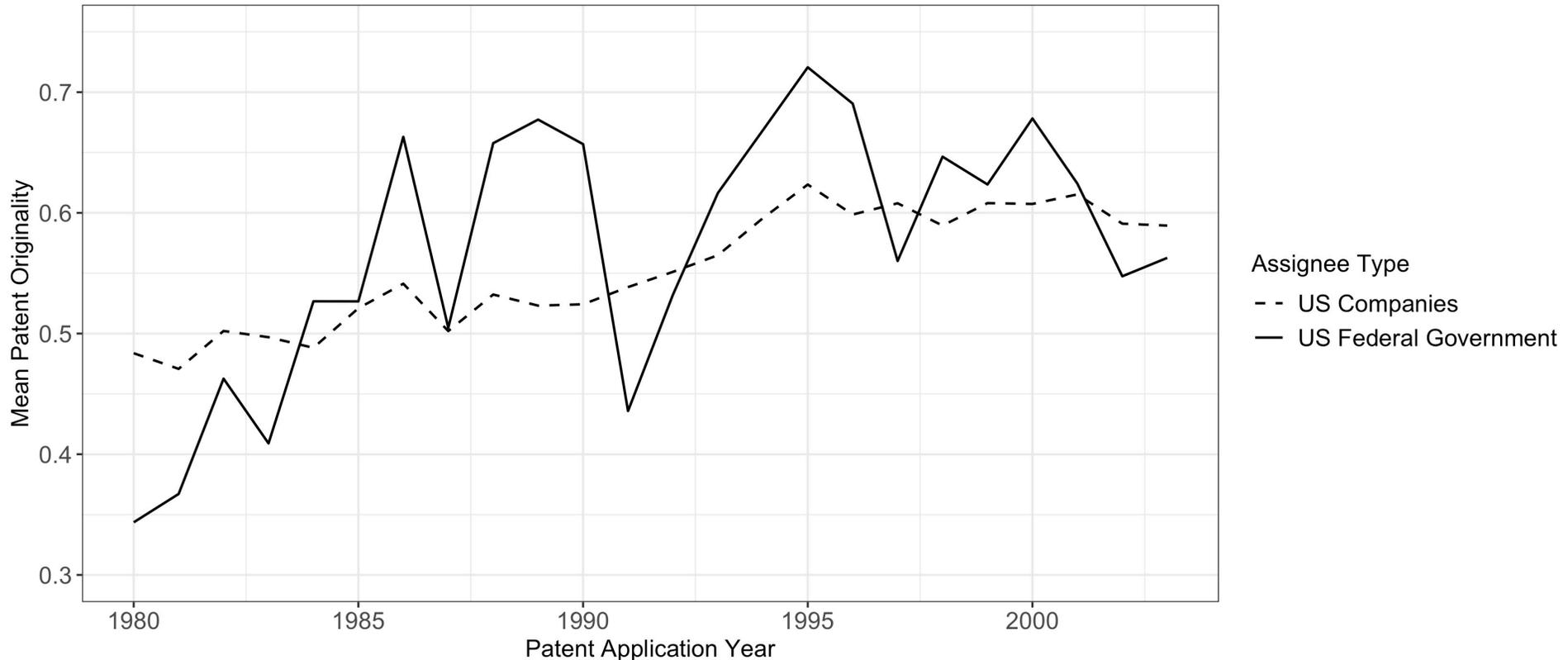
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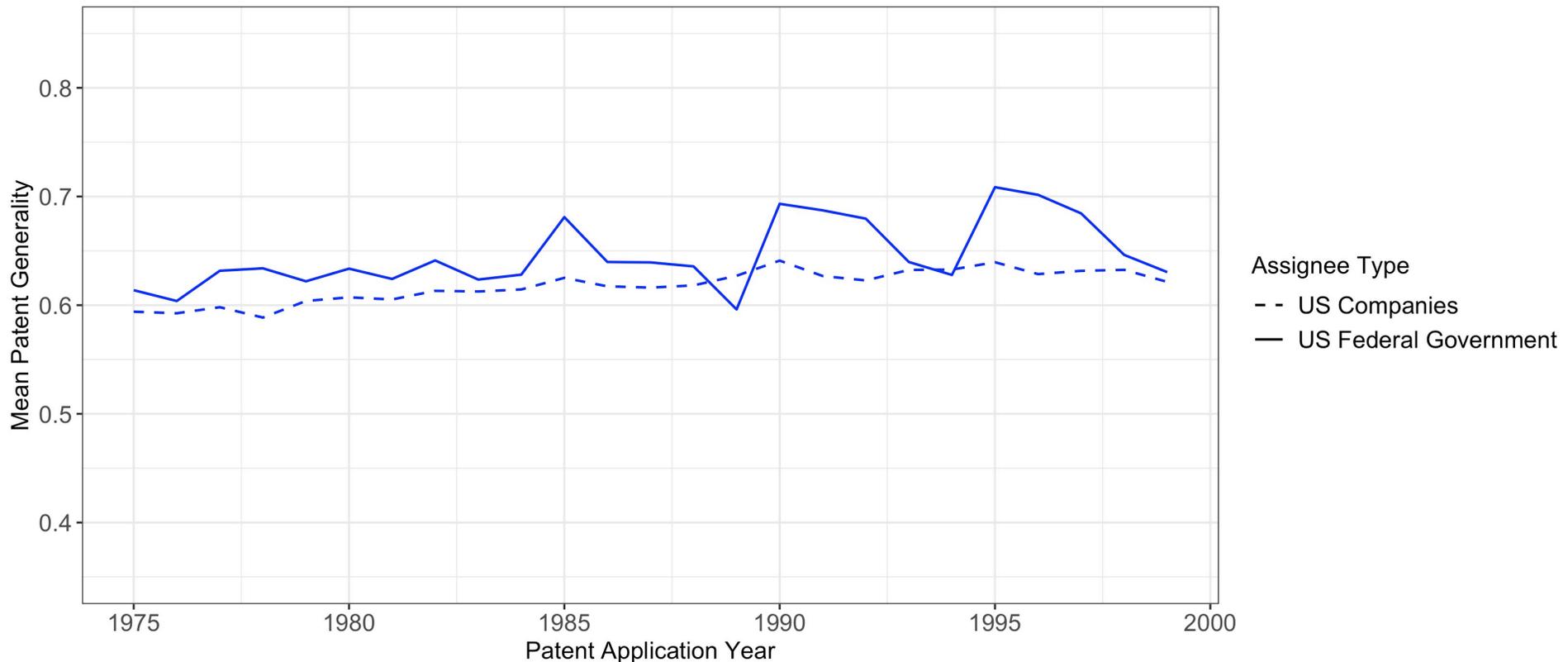
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# Government Patents Generality

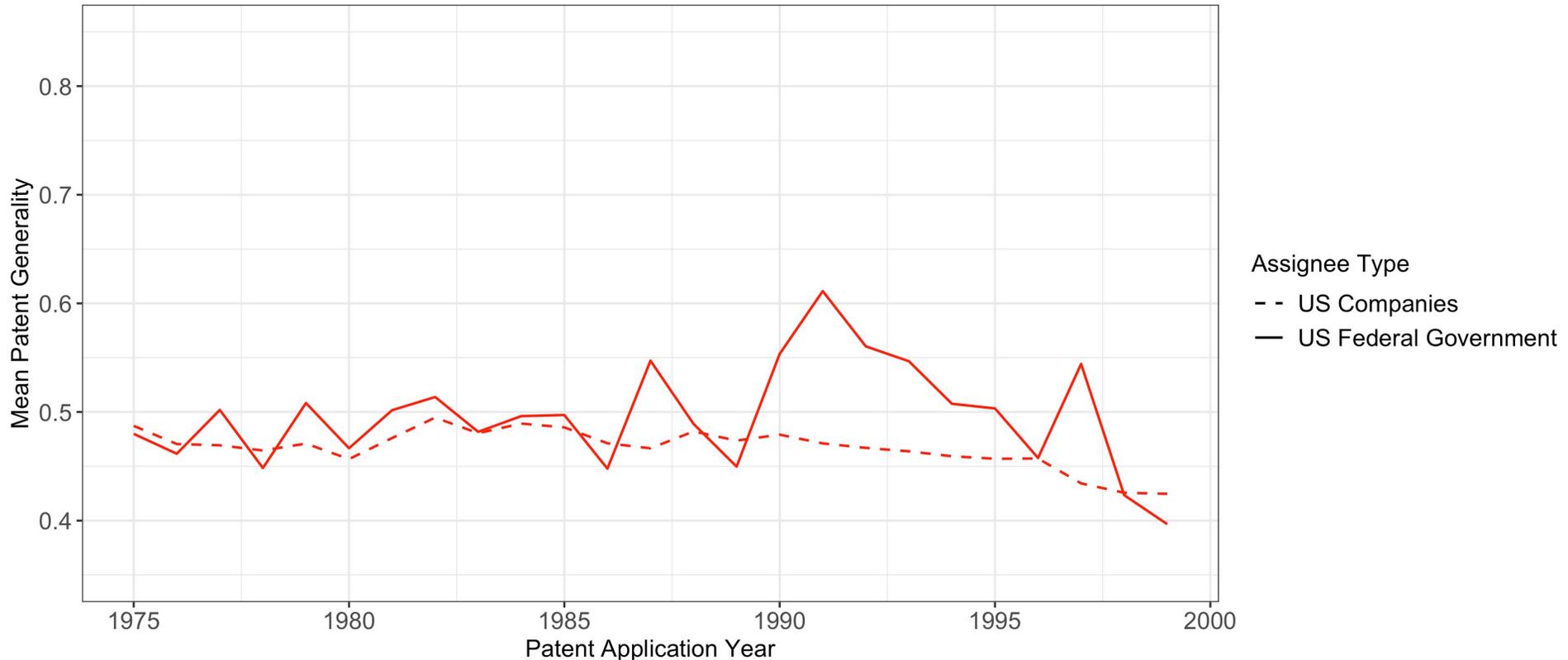
Average Patent Generality in "Measuring; Testing" Patents, 1975-1999

Generality based on breadth of patent classes citing focal patent (Trajtenberg et al. 1997).  
Patent generality scores from NBER Patent Data Project.



# Government Patents Generality

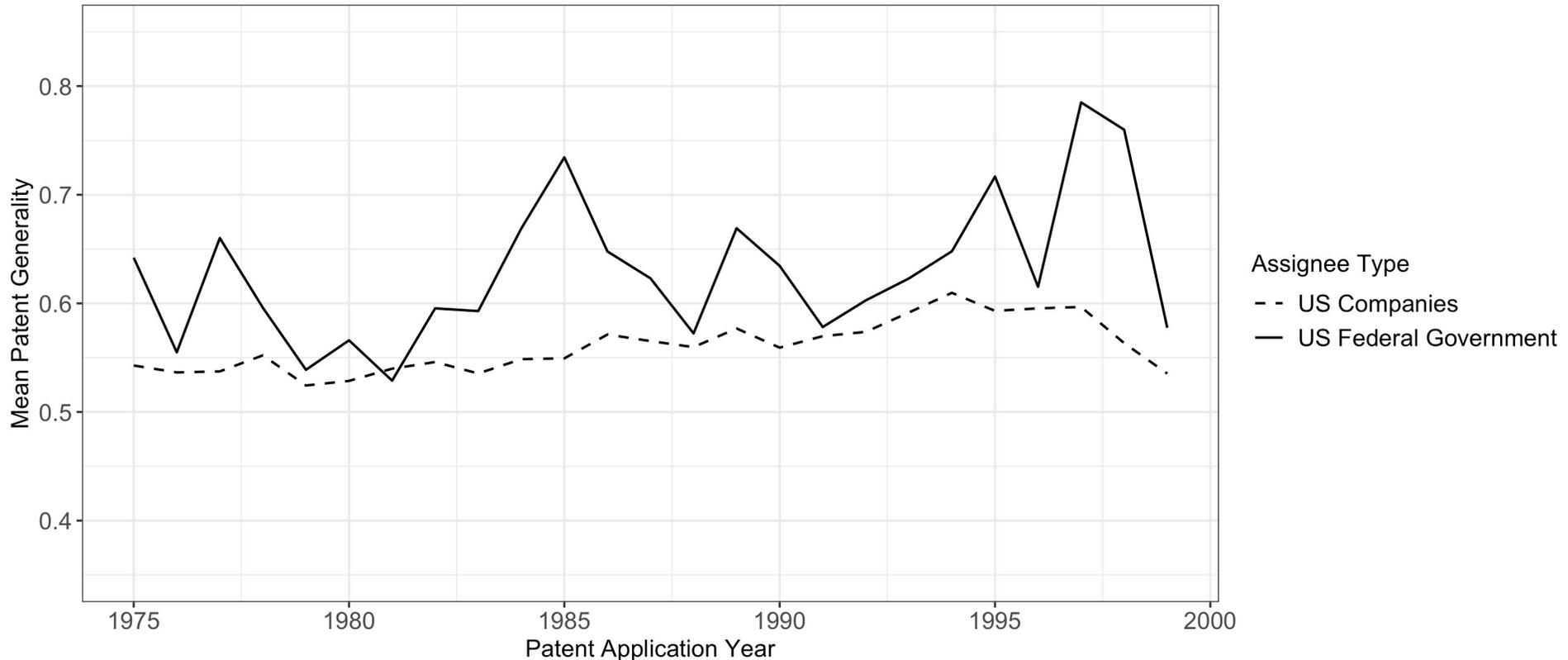
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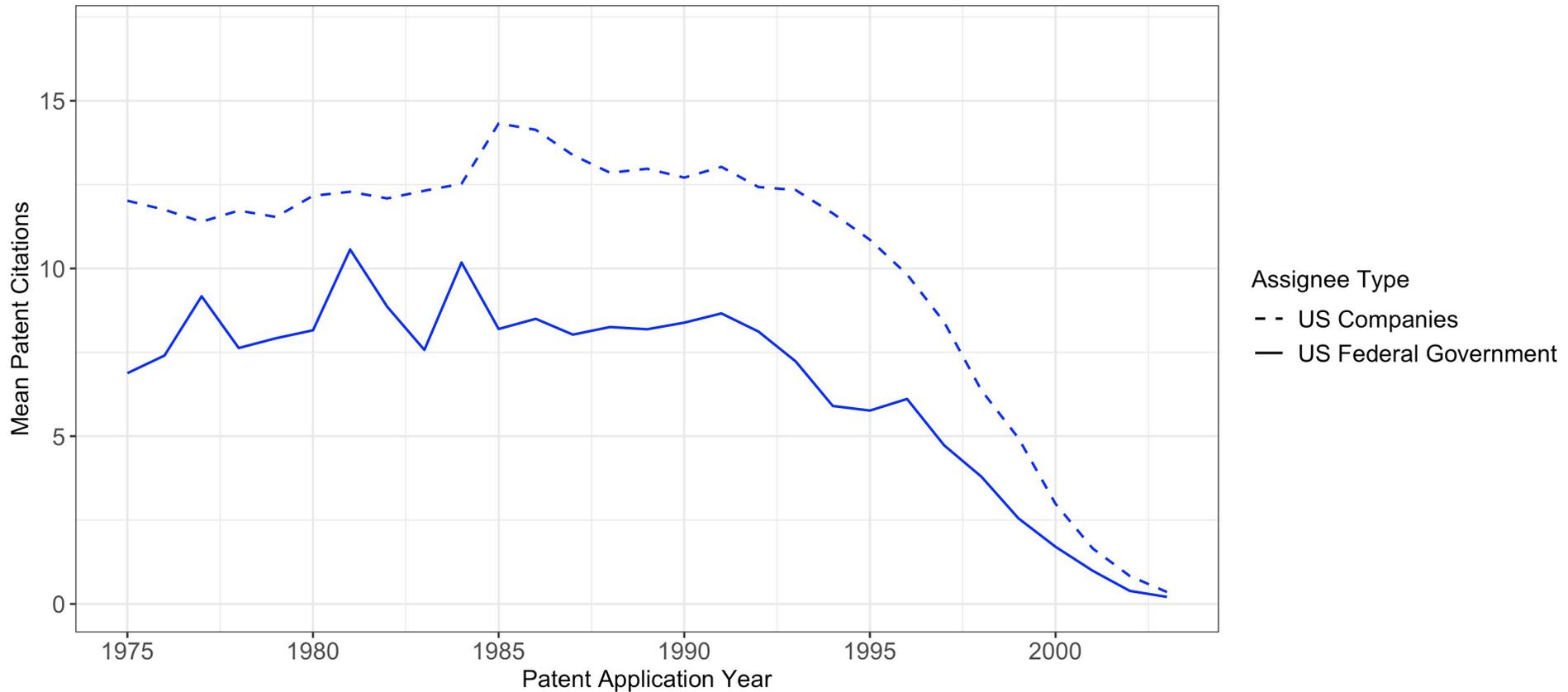
Generality based on breadth of patent classes citing focal patent (Trajtenberg et al. 1997).  
Patent generality scores from NBER Patent Data Project.



# Government Patent Quality

Average Patent Citations in "Measuring; Testing" Patents, 1975-2003

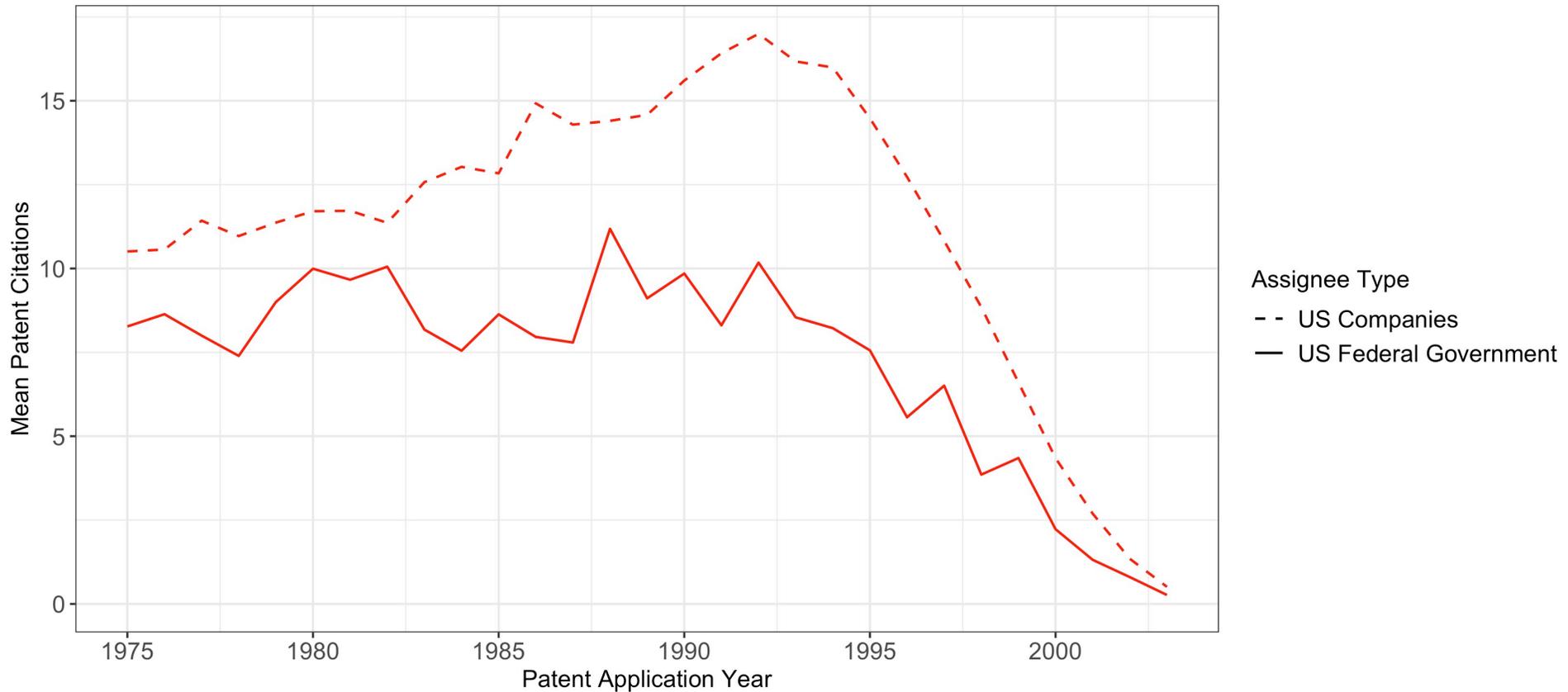
Patent citation records from NBER Patent Data Project.



# Government Patent Quality

Average Patent Citations in "Basic Electric Elements" Patents, 1975-2003

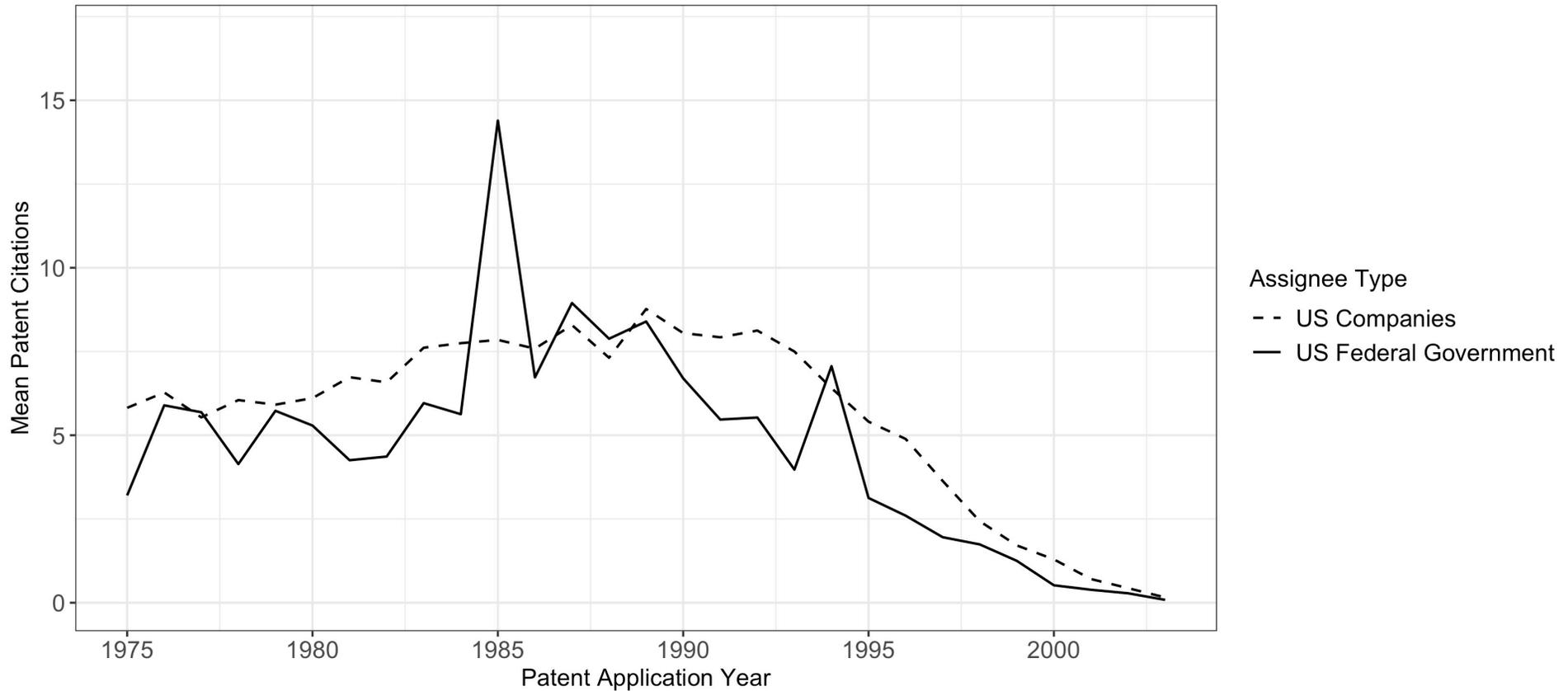
Patent citation records from NBER Patent Data Project.



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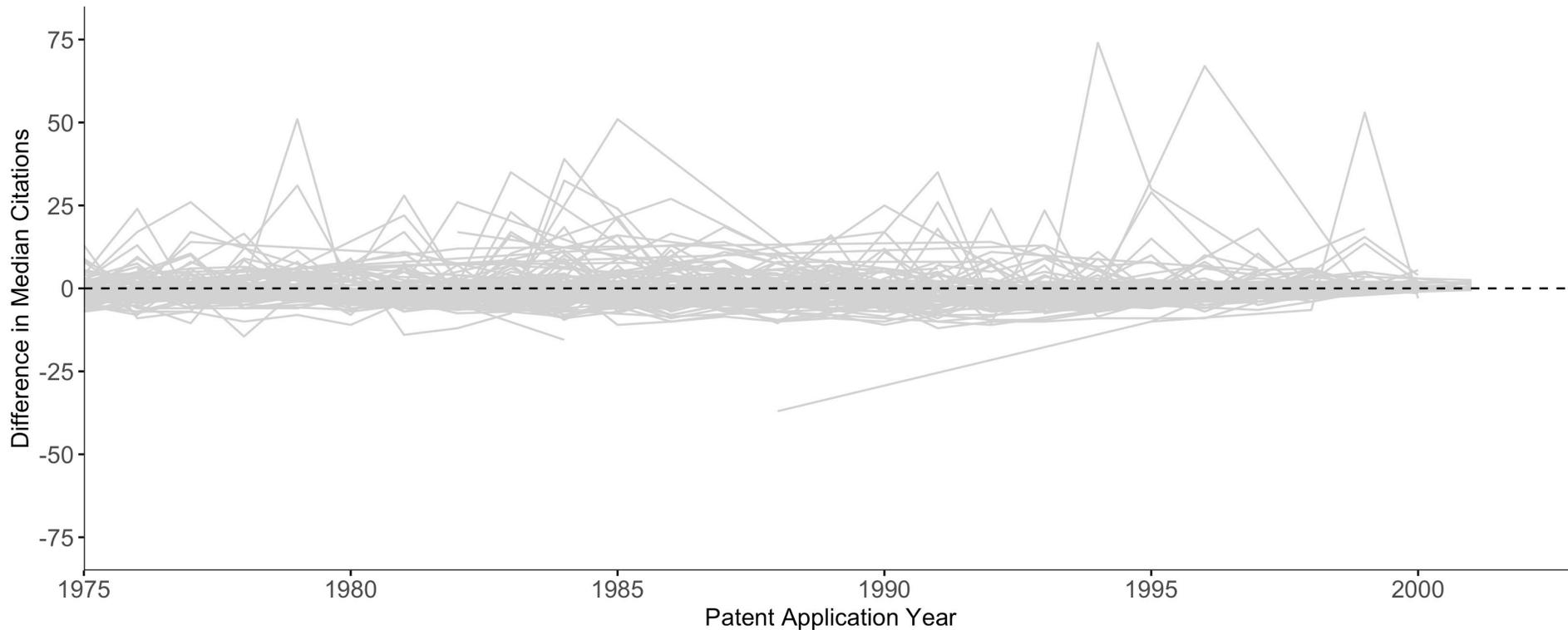
Patent citation records from NBER Patent Data Project.



# 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.

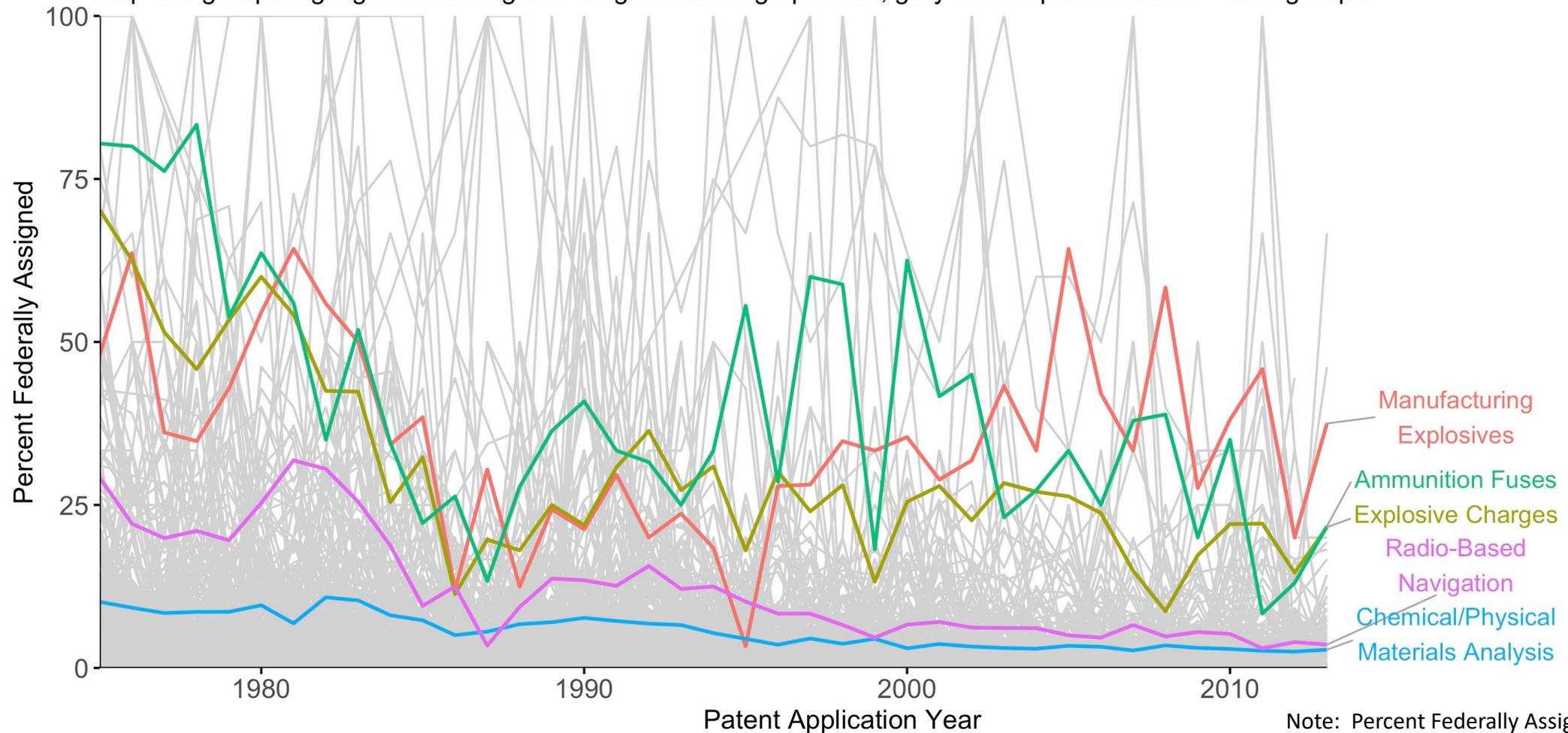


Annual difference calculated by subtracting private patent median from government patent median within each CPC subsection. Lines only plotted in years when both government and private patents are cited in the subsection.

# Government Patent Share by Technology

Percent of US Patents Assigned to Federal Government by CPC Patent Group, 1975-2013

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

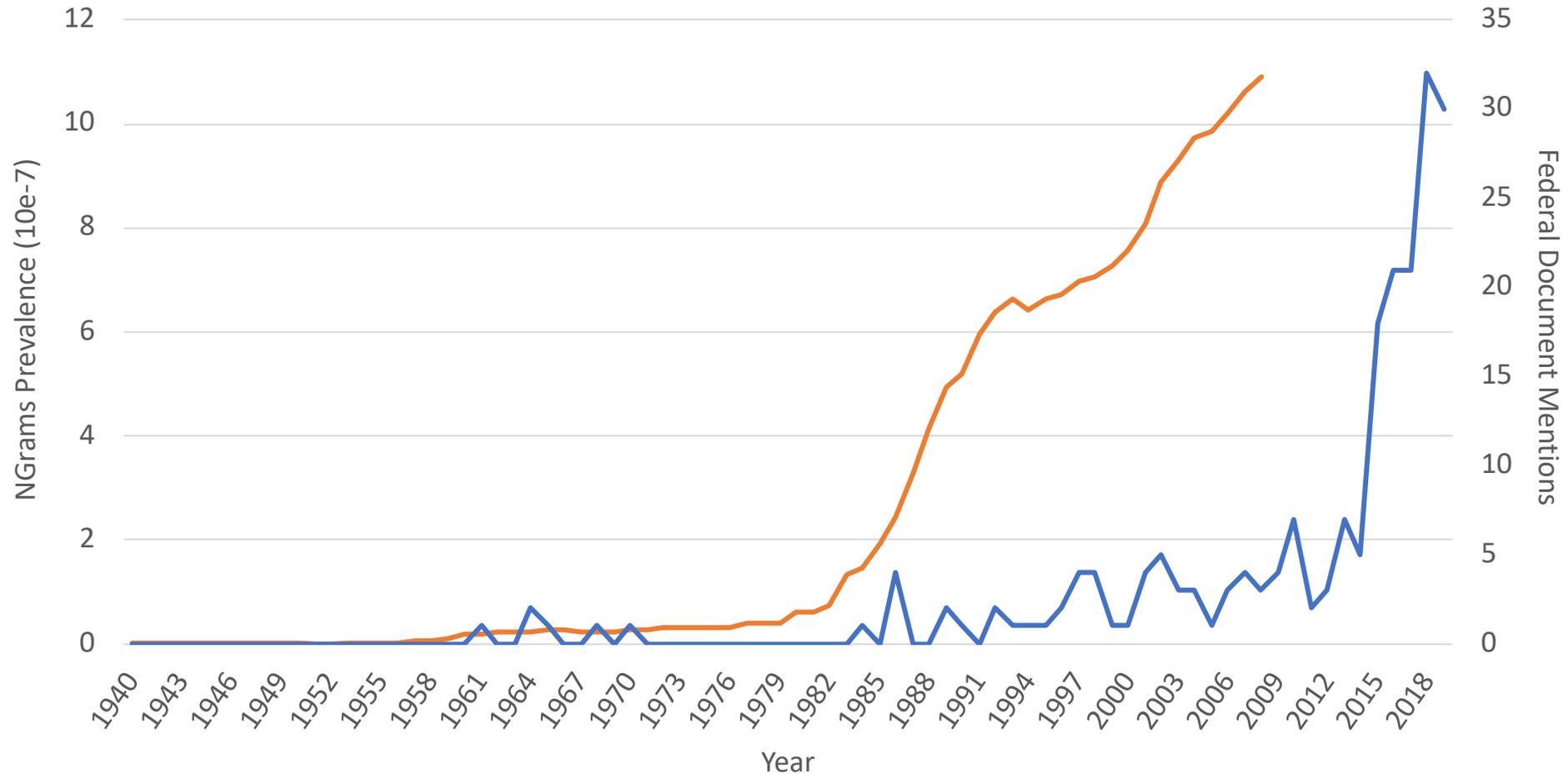


Denominator is combined patents assigned to US companies and federal government.  
Annual average weighted by number of federally-assigned patents.

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



— Google NGram Prevalence

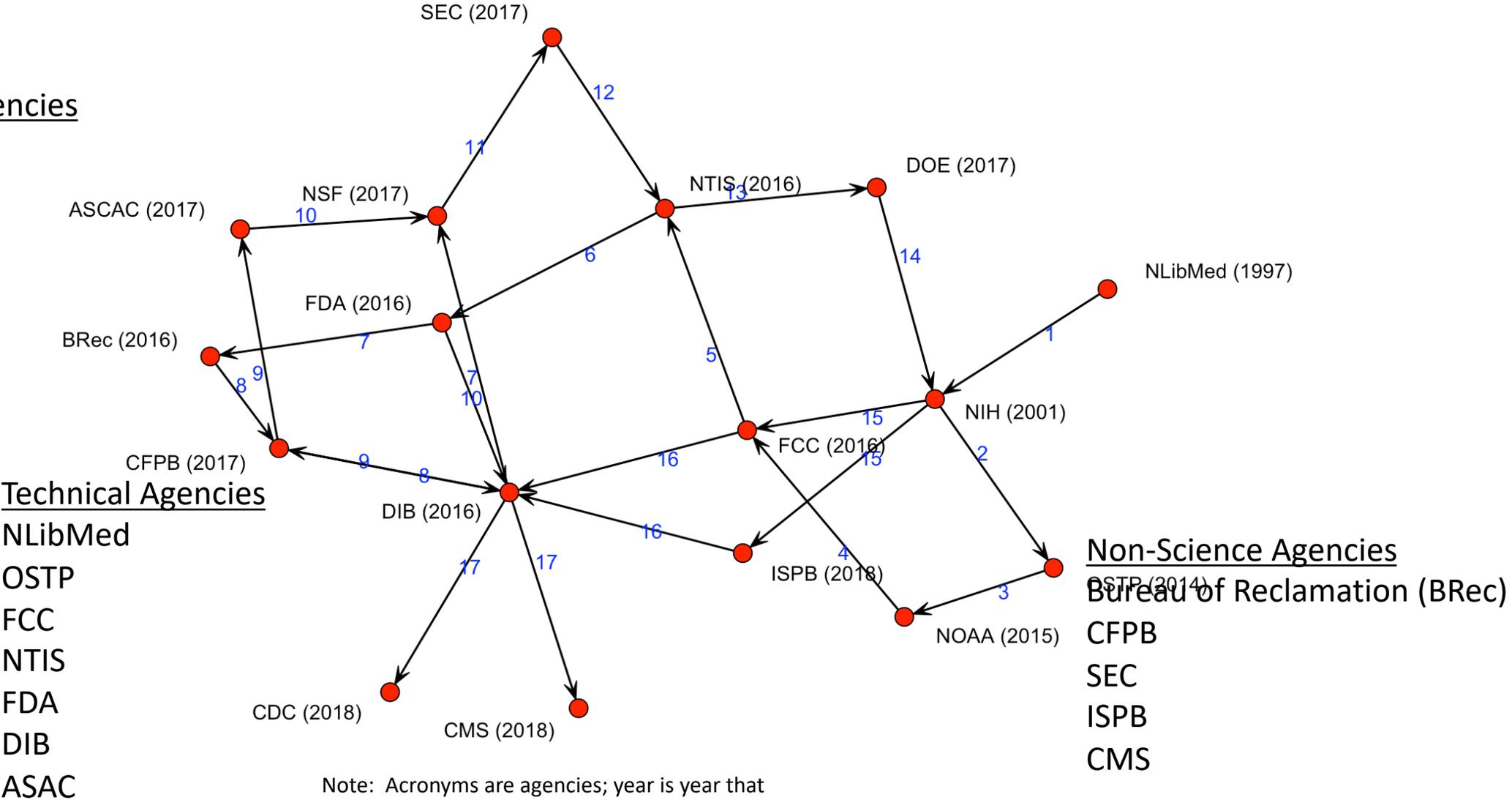
— Federal Document Prevalence

Source: Google Books NGram Viewer; Govinfo.gov

# Diffusion Across Agencies: Machine Learning

Science Agencies

- NIH
- NOAA
- NSF
- DOE
- NIH
- CDC



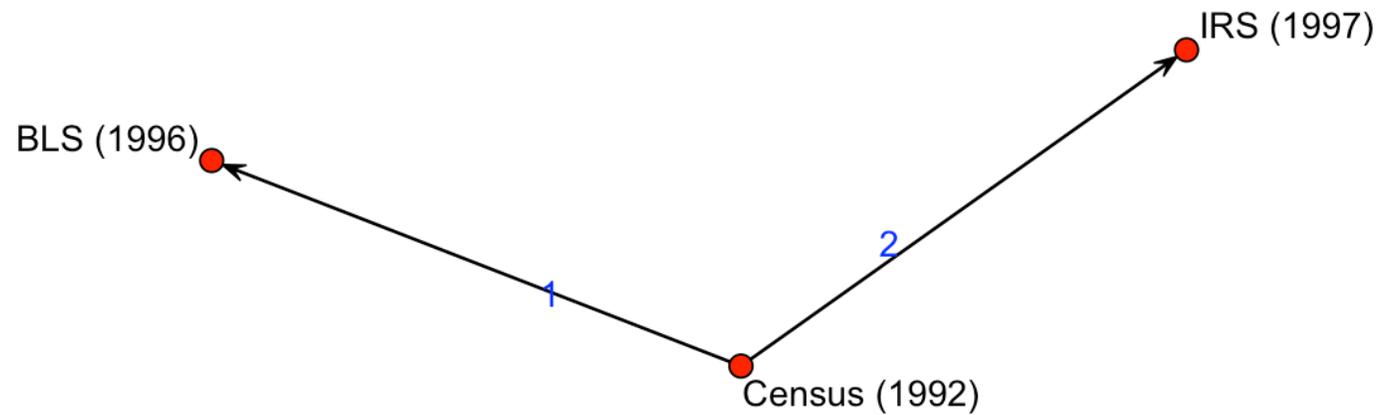
# Diffusion Across Agencies: Touchtone Data Entry

## 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](http://FederalRegister.gov)

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  - Budgets
- Outputs: Government-Assigned Patents (Hard Science/Engineering)
- Diffusion of Innovation
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