

A New Era in U.S. R&D Policy?

Explaining the Decline In U.S. Government R&D Intensity

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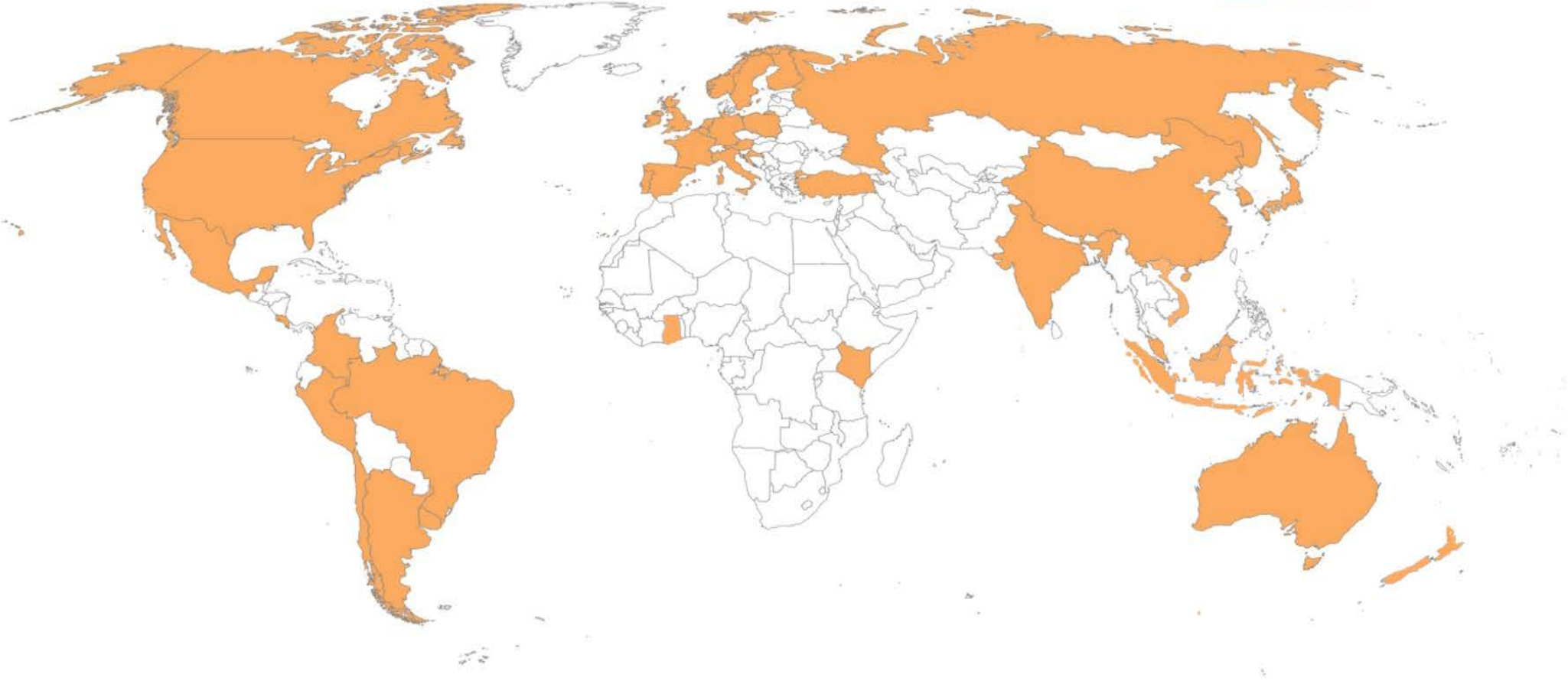
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About ITIF

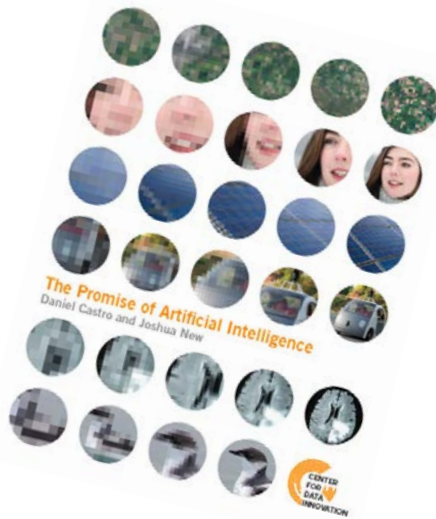
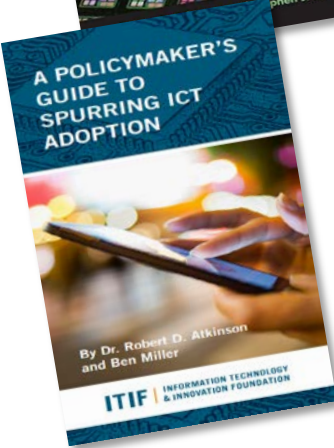
- One of the world's top science and tech think tanks
- Formulates and promotes policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress
- Focuses on a host of issues at the intersection of technology innovation and public policy:
 - Innovation processes, policies, and metrics
 - Science policy related to economic growth
 - Digital technology issues (e.g., e-commerce, e-government, e-health)
 - IT and economic productivity
 - Innovation and trade policy

ITIF Global Engagement

ITIF travel and policy engagement since 2007



ITIF Publication Highlights

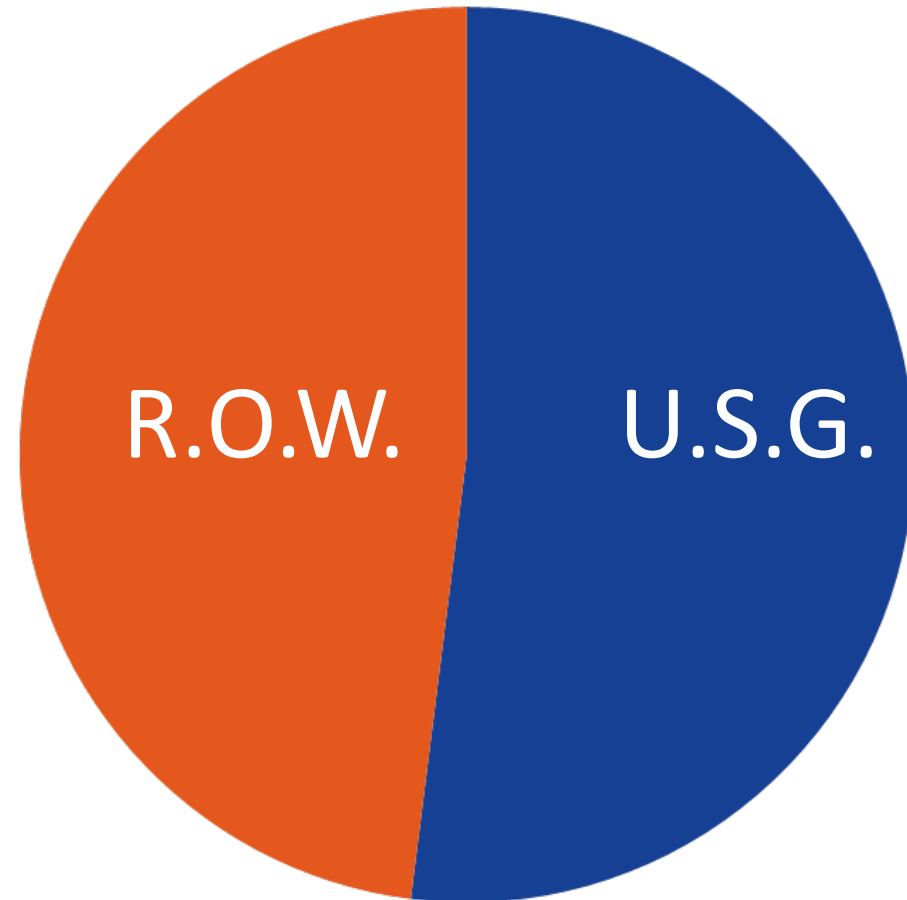


Today's Presentation

- 1 Whither U.S. Federal R&D?
- 2 Federal Cuts Matter
- 3 12 Reasons Behind the Decline?
- 4 Can it be Reversed?

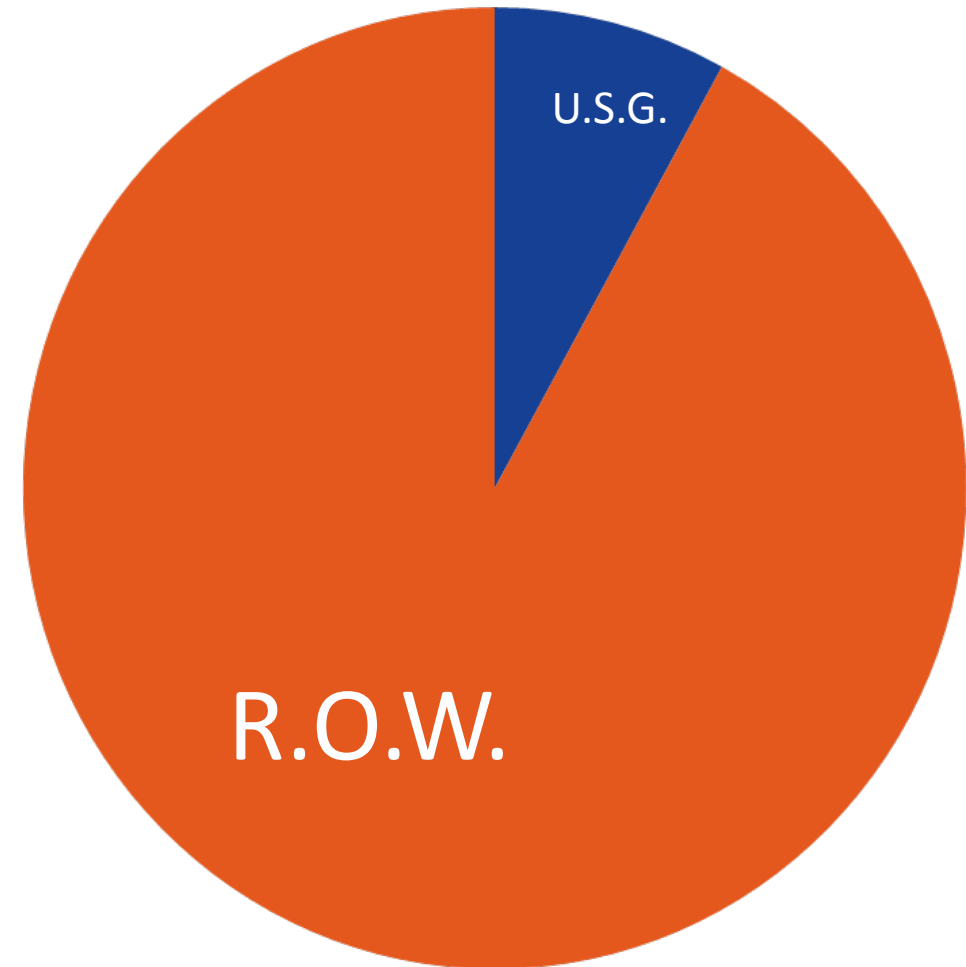
The U.S. Used To Dominate Global R&D

In the 1960s, U.S. government R&D funding exceeded the rest of the world; government and private combined.



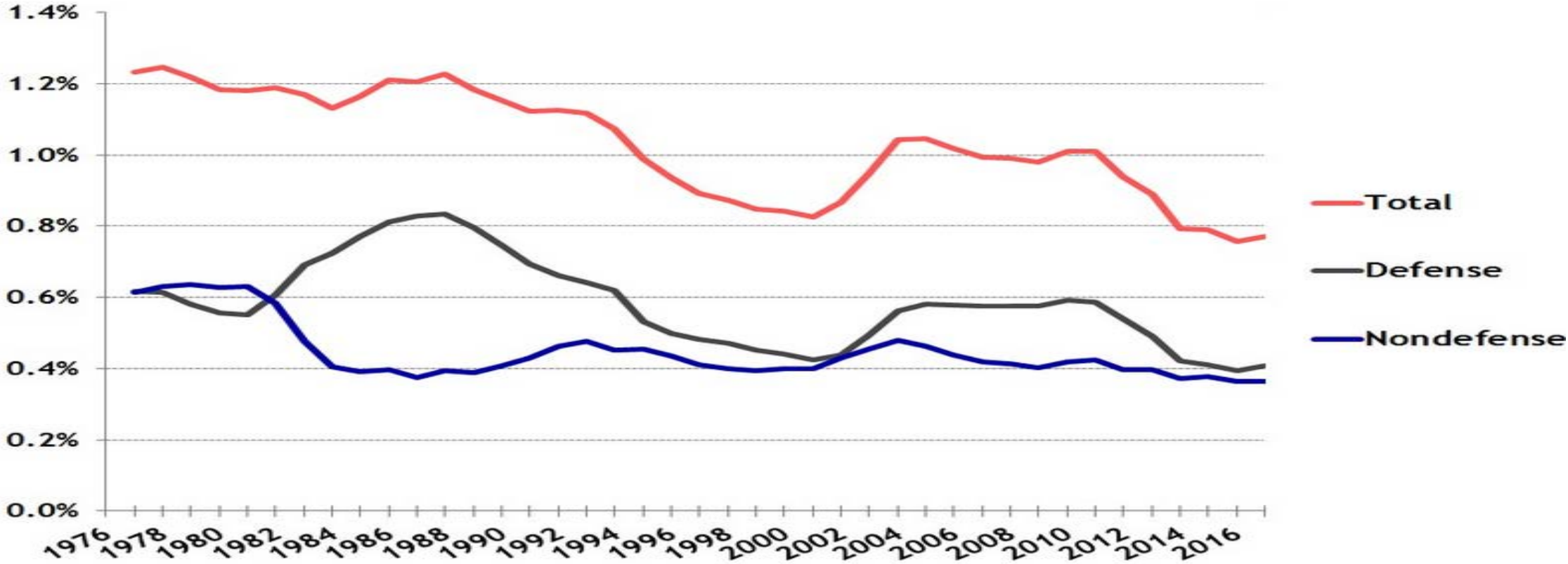
Today, USG is Just One Player

- Today, USG R&D funding accounts for just 8.4% of global R&D \$.



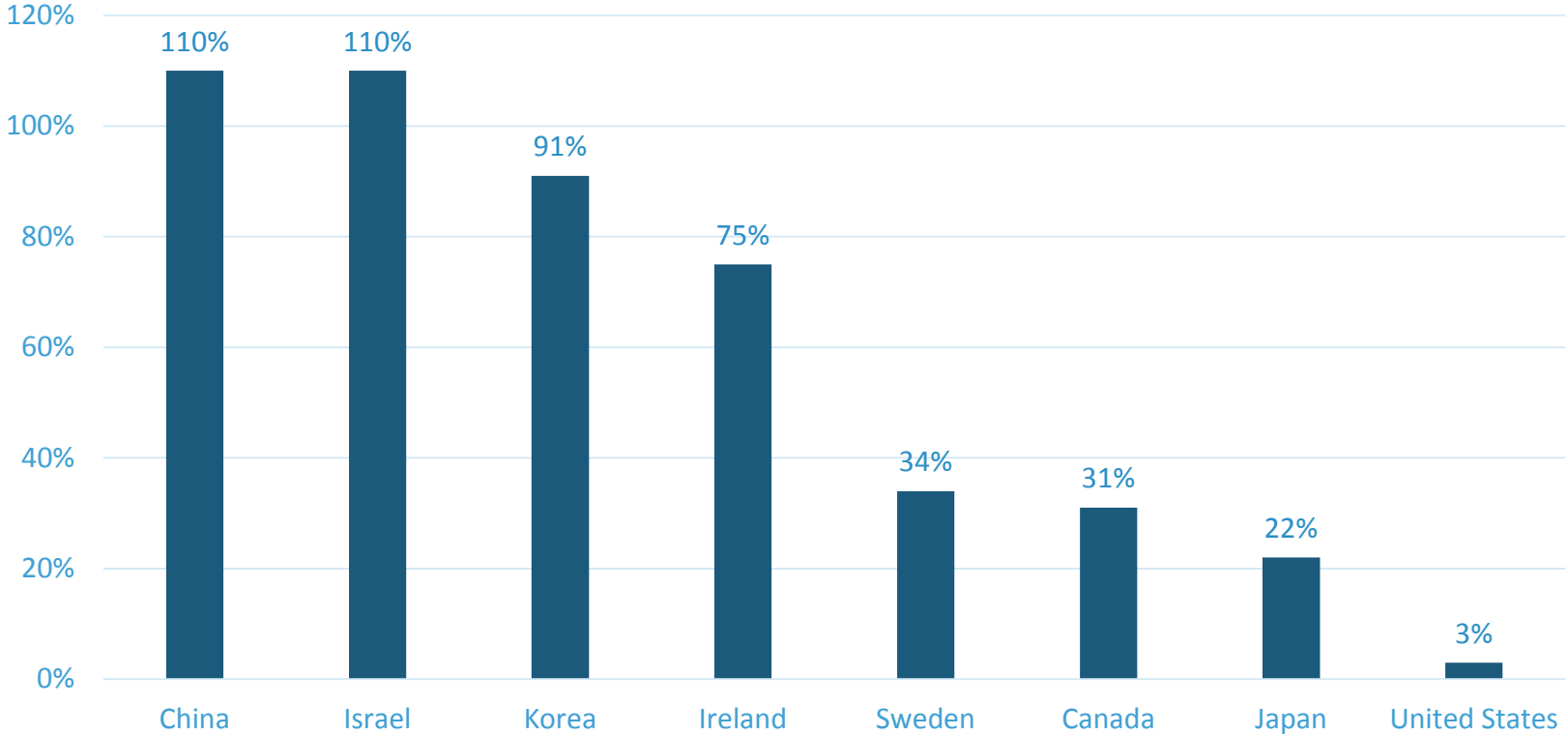
Federal R&D Intensity Has Fallen

Trends in Federal R&D
As a percent of GDP

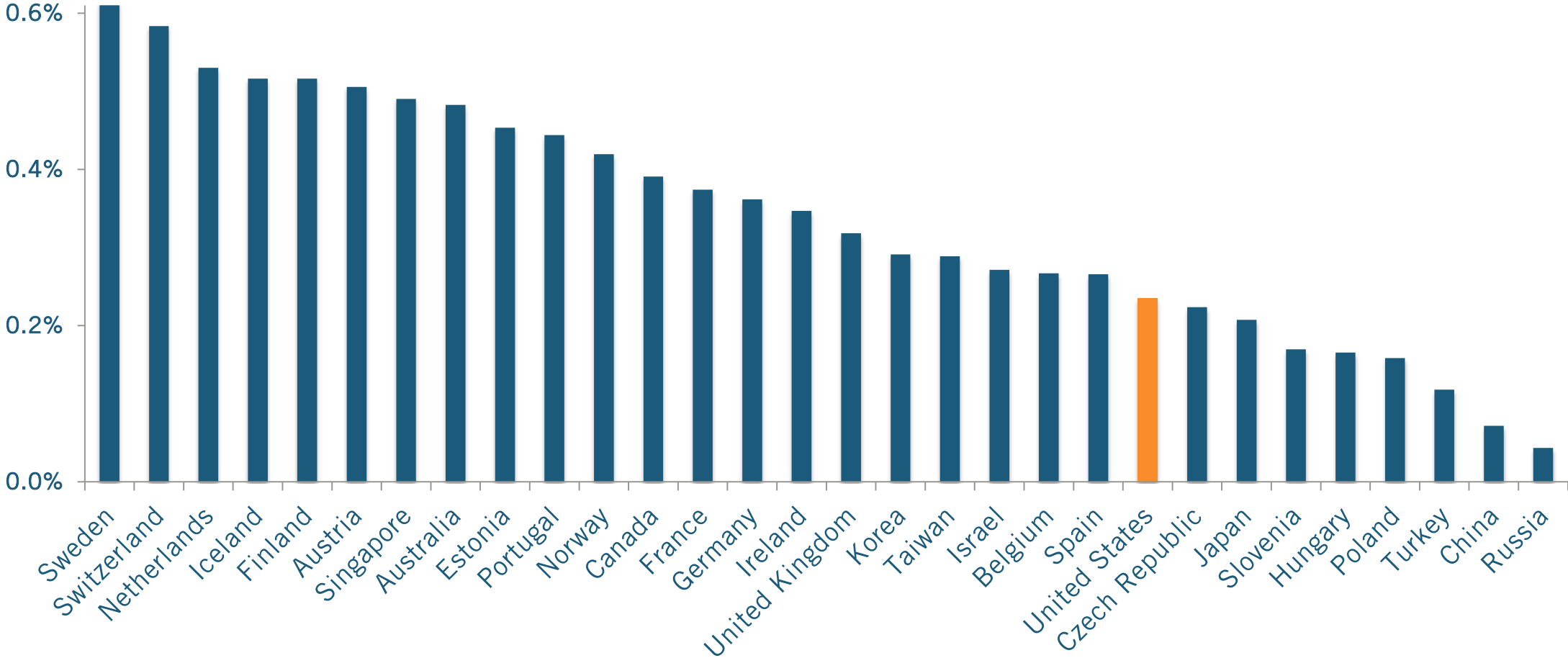


Source: Up to 1994 - National Science Foundation, Survey of Federal Funds for Research and Development; 1995 to Present - AAAS data. GDP figures are from *Budget of the U.S. Government FY 2016*. FY 2015 and FY 2016 figures are estimates. © 2015 AAAS

Other Nations Increased Their R&D Investment (2000-2012)



Other Nations Invest More in University Research

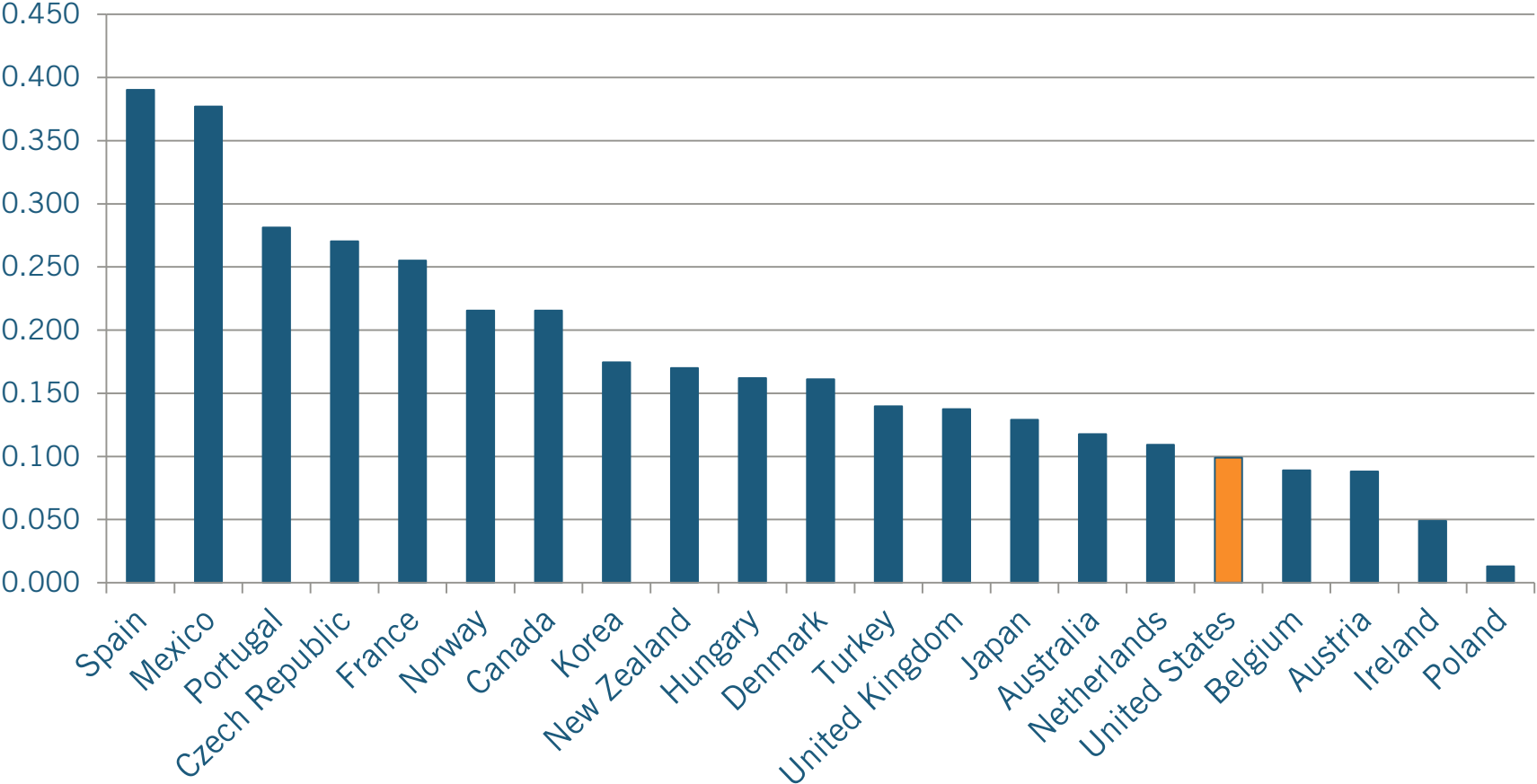


Source: ITIF Report: *University Research Funding: The United States is Behind and Falling*, May 2011 (as share of GDP)

Other Nations Have National Innovation Agencies

Country	Has Articulated a National Innovation Strategy?	National Innovation Agency/Foundation	Year Agency Introduced
Brazil	Yes	Brazil Innovation Agency	1967
China	Yes	Ministry of Science and Technology	1998
Denmark	Yes	Danish Agency for Science, Technology, and Innovation	2006
Finland	Yes	TeKes	1983
France	Yes	OSEO	2005
India	Yes	National Innovation Foundation	2000
Ireland	Yes	Forfas	1994
Italy	Yes	ENEA (National Agency for New Technologies, Energy and the Environment)	1999
Japan	Yes	New Energy and Industrial Technology Development Organization (NEDO)	1980
Korea	Yes	Korea Industrial Technology Foundation	2001
The Netherlands	Yes	Senter Novem	2004
Norway	Yes	Innovasjon Norge	2004
Portugal	Yes	Agência de Inovação	2003
South Africa	Yes	National Advisory Council on Innovation	2006
Sweden	Yes	VINNOVA	2001
Taiwan	Yes	Industrial Technology Research Institute	1973
Thailand	Yes	National Innovation Agency	2003
United Kingdom	Yes	Department of Business, Innovation, and Skills	2009
United States	Yes	N/A	N/A
Uruguay	Yes	National Research and Innovation Agency (ANII)	2008

Other Nations Have More Generous R&D Tax Incentives



Source: ITIF Report: *We're #27!: The United States Lags Far Behind in R&D Tax Incentive Generosity*, July 2012

Whither US Federal R&D?

- Universities are increasingly turning to non-federal sources for support (philanthropy, corporations, etc.).
- Risks leading to downward cycle: less money from feds, less interest in lobbying feds for more money, even less money from feds....

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Whither U.S. Federal R&D?

2

Federal Cuts Matter

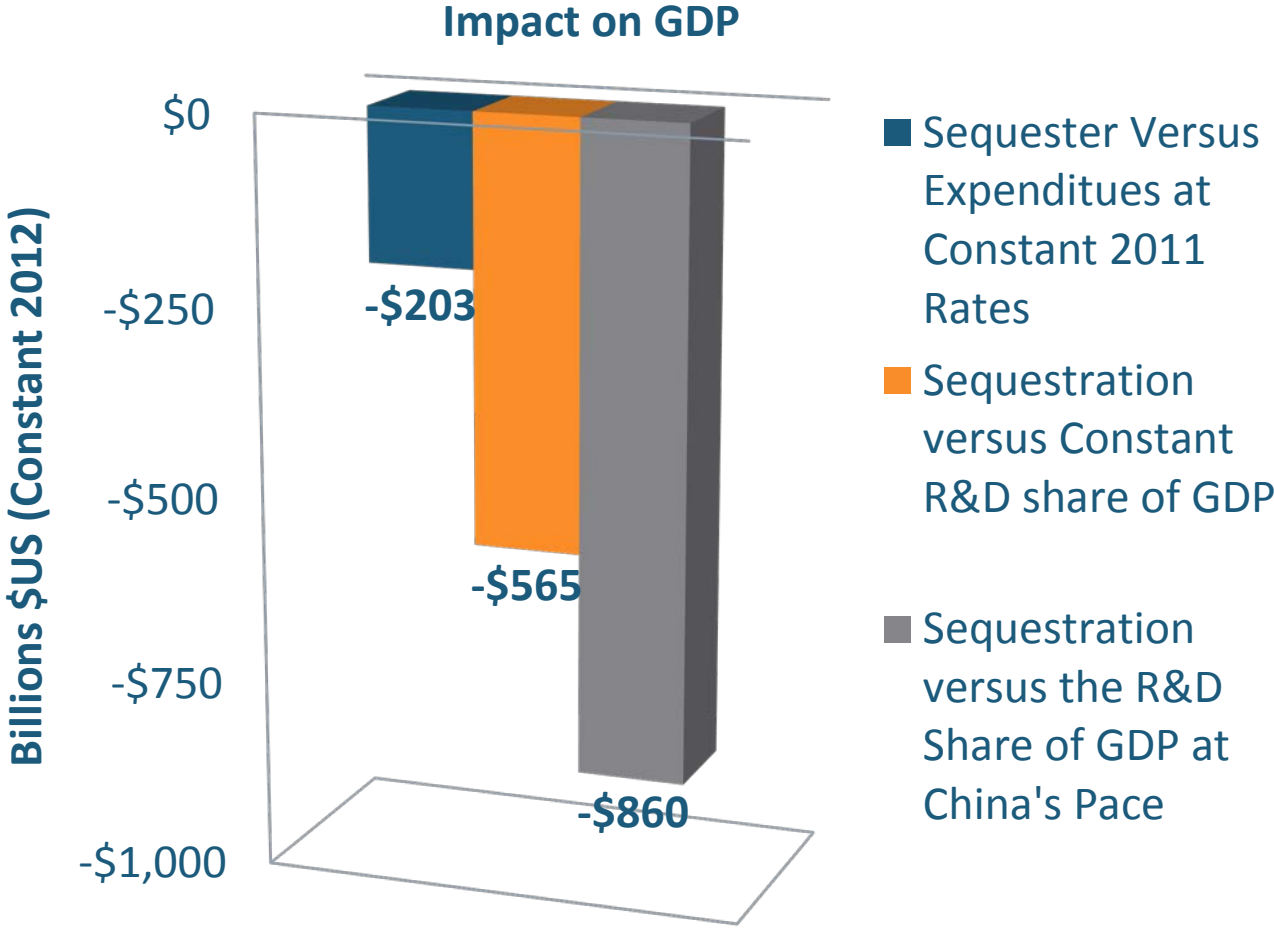
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12 Reasons Behind the Decline?

4

Can it be Reversed?

R&D Cuts Reduce GDP



R&D Funding Shortfalls and the Related Losses in Real GDP 2013-2021 Cumulative Effect, Sources: NSF, OMB, CBO, BEA, ITIF

R&D Cuts Reduce New Knowledge

	Journal Publications	Patents
2013	-9.2%	-3.3%
2013-2021	-7.8%	-2.8%

(Sequestration Compared to CBO Baseline)

Federal R&D Paid Off in These Innovations

- Google Search Engine
- GPS
- Supercomputers
- Artificial Intelligence and Speech Recognition
- ARPANET: Foundation of the Internet
- Closed Captioning
- Smartphone Technologies
- The Shale Gas Revolution
- Seismic Imaging
- Visible LED Lighting Technology
- Magnetic Resonance Imaging (MRI)
- Advanced Prosthetics
- The Human Genome Project
- HIV/AIDS
- Reverse Auctions
- Kidney Matching Program
- Fast Multipole Method
- Learning Science Advances
- Civilian Aviation
- Hybrid Corn
- Lactose Free Milk

And These Companies

1. Google
2. iRobot
3. Genentech
4. Cisco Systems
5. SAS
6. iRobot
7. Cisco Systems
8. Sun Microsystems
9. Praxis Biologics
10. Orbital Sciences
11. Lehigh Nanotech
12. Xenogen
13. Momenta Pharm.
15. Big Stage Entertainment
16. Chromatin, Inc.
17. Cognex, Inc.
18. Aursos, Inc.
19. FAST Diagnostics
20. FluGen, Inc.
21. Kionex, Inc.
22. Response Gen.
23. Protea Bioscience
24. ONY, Inc
25. Solamer Energy
26. Spin Transfer Technologies.
28. Vaccinex, Inc.
29. MicroMRI, Inc.
30. Maroon Biotech
31. ImagiSonix
32. Immuneworks
33. Pacific Biosciences
34. Universal Display Corp.
35. Triangle Pharma
36. Sinmat
37. ALEKS Corp.
38. A123 Systems

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Can it be Reversed?

1) Loss of U.S. National Mission

- **1776 to 1940:** *Building a Nation:* established Patent Office, military armories; 1862 Morrill Act to establish land grant universities; relatively large role for industry and foundations in funding university R&D; military funding for aviation and navy.
- **1940 to 1990:** *Defending a Nation:* Rise of federal science system with Office of Scientific Research and Development, evolving into NSF; Soviet threat spurring large increases in mission-oriented research funding for DOD, DOE and NASA.
- **1979 – 1995:** *Competitiveness Interlude:* increased focus on tech commercialization; NSF ERC's and IURCs; Stevenson-Wydler Act; Bayh-Dole).
- **1995 - present:** *Adrift:* no perceived commercial or military external threat to mobilize innovation greatness.

2) Neo-Classical Economics Ignores, Dismisses and Misunderstands Technological Innovation



3) Rise of Science Libertarianism

- Silicon Valley guru Peter Diamandis acknowledges that federal research funding spurred past innovations, but now, it just gets in the way. Better to rely on super-rich magnates such as Elon Musk to fund research.
- Michael Arrington, former editor of the widely read Silicon Valley blog *Tech Crunch*, says Washington should “just leave Silicon Valley alone.”
- Matt Ridley, a libertarian conservative member of the British House of Lords, writes: “there is still no empirical demonstration of the need for public funding of research.”

Science Libertarianism is Flawed

- Postulates that federal R&D “crowds out” business R&D.
- In fact, on average ever dollar of federal R&D “crowds in” 30 cents of business R&D.
- U.S. business R&D shifting to “D” (basic & applied to development ratio fell from 34 to 27% from 2008 to 2013

4) Progressives Have Other Priorities

- Despite lip service to increased federal funding, progressives have more important priorities (breaking up big companies, fighting the culture and identity battles; expanding entitlements (including health care and retirement security) and increased social services spending.
- And are unlikely to support increased defense R&D.

5) The Government Bank is Overdrawn

- Budget deficit: \$443 billion. National debt: \$13.6 trillion.
- Republicans won't raise taxes on individuals.
- Democrats won't cut entitlement spending.
- Voters will vote against any politician that tries to do either.

6) Global Research Efforts Are Getting Less Productive

- Total research effort grown by 23 times since 1930.
- Research effort for semiconductors has risen 78 times since 1971.



(Bloom, Jones, Van Reenen and Web, 2017)

6) Global Research Efforts Are Getting Less Productive

Of 40 MIT predictions from 2001 to 2005 for “Breakthrough Technologies” only:

- 1 is greater than \$100 billion in sales (data mining)
- 3 are greater than \$10 billion (smart grid, biometrics, cloud)

(Source: Jeffry Funk, <http://www.slideshare.net/Funk98/mits-poor-predictions-about-technology>)

6) Global Research Efforts Are Getting Less Productive

- “Idea” total factor productivity (TFP) falls in half every 13 years.
- Idea TFP fallen by a factor of 48 since 1930.
- The growth rate of Moore’s Law has remained constant. The number of researchers required to achieve the doubling of chip density today is more than 75 times larger than the number required in the early 1970s

Why is Research Productivity Is Declining?

- Wrestling secrets from nature becomes ever harder
- Duplication of efforts.
- Exhaustion of the current s-curve
- Pressures on companies to focus more on later stage research

7) Too Many Nations Free Ride on U.S. Knowledge Creation

- Most nations invest less in basic and more in applied and development.
- Many nations steal American intellectual property.
- Many nations do a better job of commercializing U.S. discoveries.

8) Growth in Science Skepticism

- Right: Climate change; STEM cells; evolution

- Left: Genetic modifications of organisms; cell phone radiation; animal testing; vaccinations; nuclear power

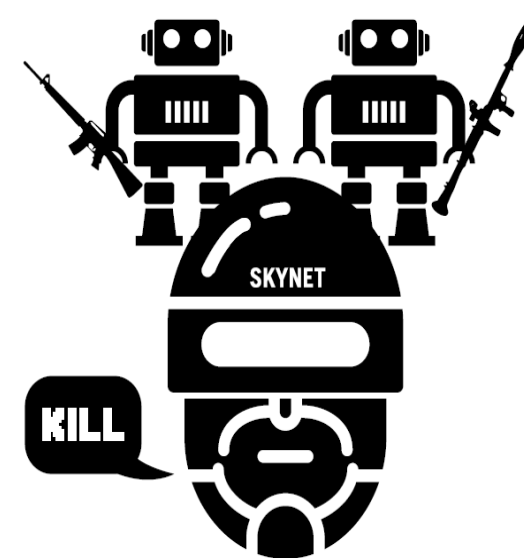
8) Revival of Neo-Ludditism, Including in the Academy

- “...half the jobs ... might be eliminated by innovations such as self-driving vehicles, automatic checkout machines and expert systems. (Larry Summers)
- “Highly educated workers are as likely as less educated workers to find themselves displaced.” (Paul Krugman)
- Yale’s Robert Schiller calls for tax on robots.



Why Fund CS Research When Computers Will Likely Kill Us?

- AI could be “the demon” that threatens our existence.” — (Elon Musk)
- “AI will evolve to superintelligence and kill us all.” — (Nick Bostrom, *Superintelligence*)
- “A malevolent superintelligence may attempt to abuse and torture humankind with perfect insight into our physiology to maximize amount of physical or emotional pain.” — (Roman V. Yampolskiy, University of Louisville)



9) Low Optimism About Science

- World Values Survey: “Science and technology are making our lives healthier, easier, and more comfortable”: Completely Agree
- United States: 12.6%
- Japan: 13.1%
- Netherlands: 13.2%
- South Korea: 18.9%
- Germany: 19.6%
- Taiwan: 21.6%
- China: 23.0%
- Sweden: 25.4%
- Australia: 25.6%

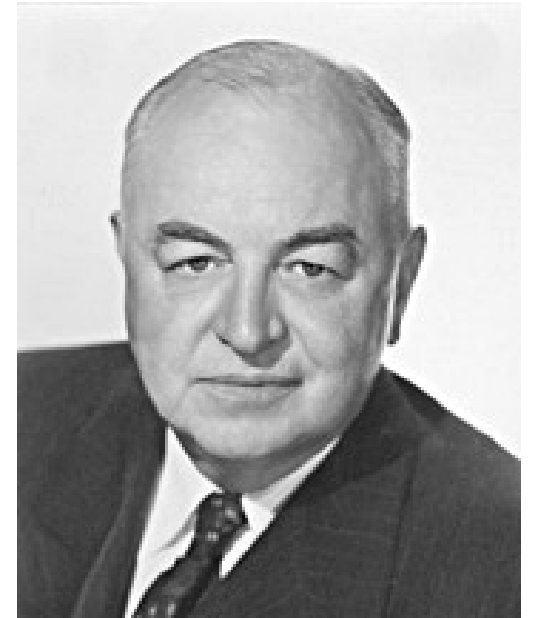
10) Limitations of the Vannevar Bush Linear Model

- Best science had to be elitist in the sense of supporting the most excellent scientists; it had no formula for geographic distribution; and no real attempt to prioritize science with largest economic impact
- Polanyi's "The Republic of Science": "any attempt at guiding scientific research towards a purpose other than its own is an attempt to deflect it from the advancement of science."

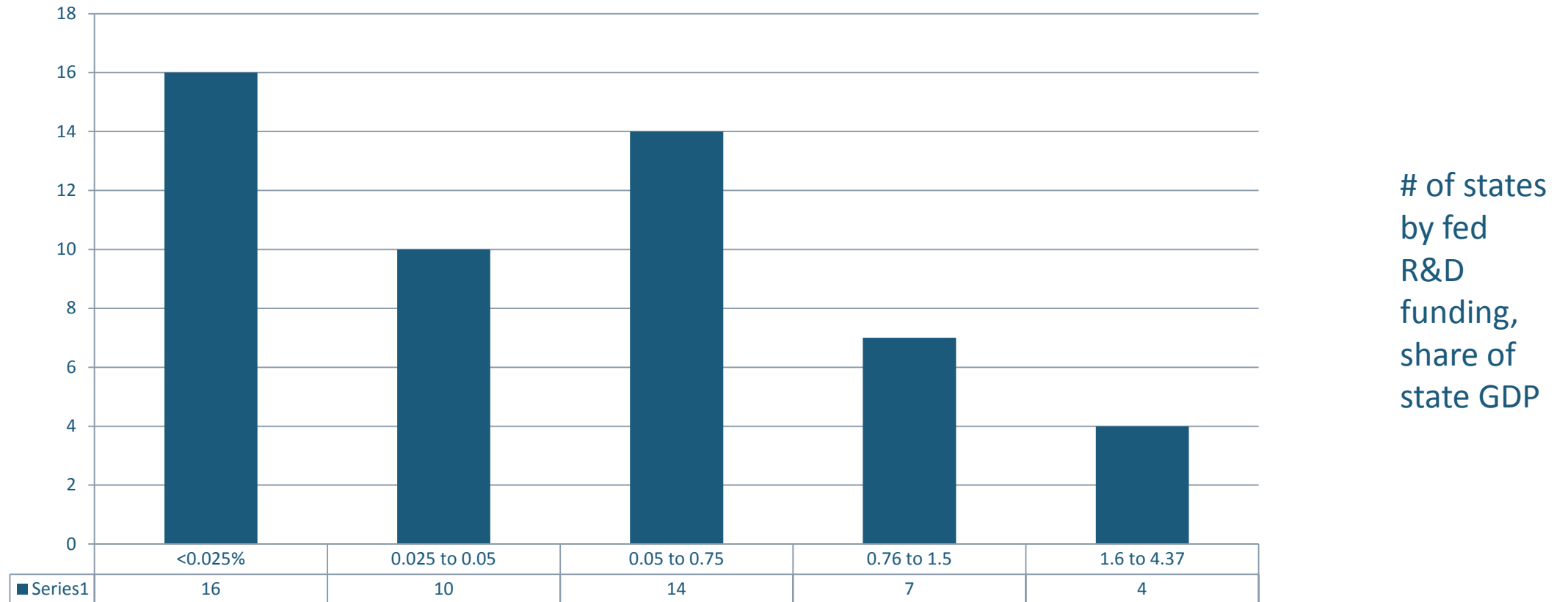


Time to Move Towards Sen. Harley Kilgore's Vision?

- Refusal to accept constraints to align funding to national priorities or to evaluate proposals based on expected technological and economic impact hurts political support.
- Need more geographic distribution of federal R&D.
- Need more R&D to solve national problems
 - On a per GDP basis, Korea invests 89 times more than the US on industrially-oriented research, Germany 43 times more, and Japan 15 times more.

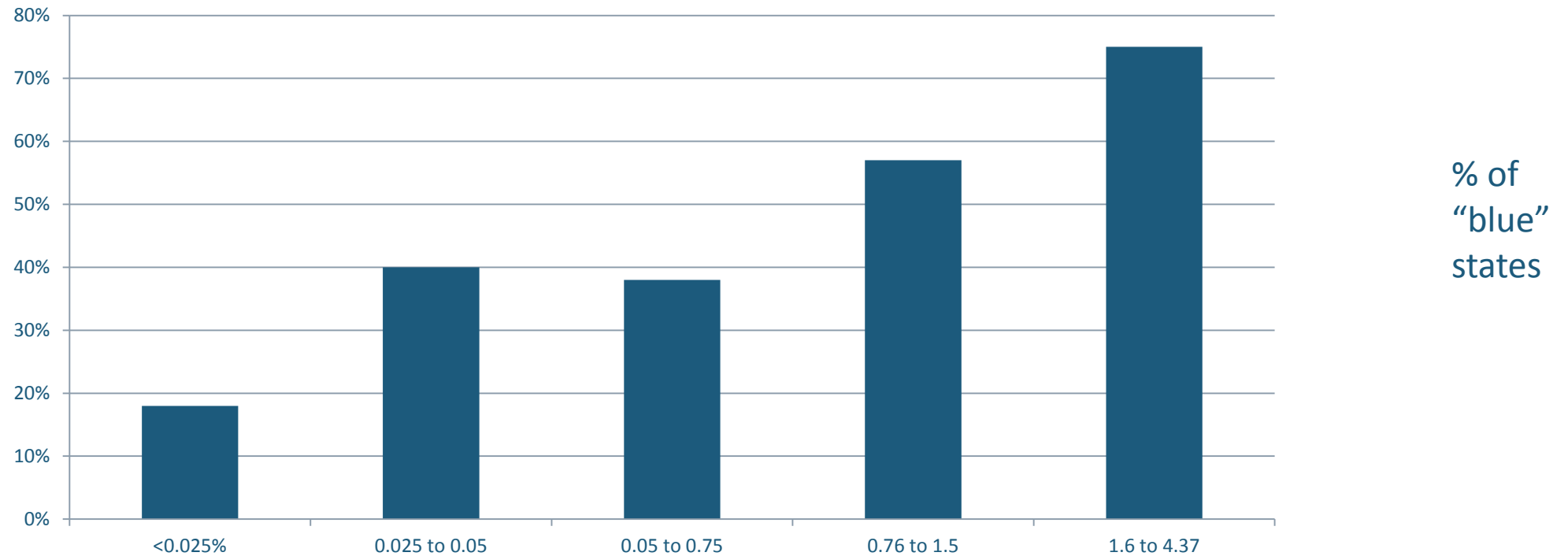


11) Federal R&D Funding Is Tilted to a Few States



National Science Foundation, 2016

11) Federal R&D Funding Is Tilted to “Blue” States



Source: National Science Foundation

12) Academia Perceived to be at Odds With Mainstream America

- Suspicion of capitalism and business
- Embrace of left-wing political correctness and demonization of conservatives.
- ...Not a good formula for getting support in Washington.



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Can it be Reversed?

Prospects?

- Budget situation will get worse before better.
- Political polarization unlikely to ameliorate.
- Maybe a new national threat emerges (e.g., Chinese military challenge; marked fall in U.S. competitiveness).
- Maybe pragmatic, pro-growth president elected in 2020?
- Otherwise, status quo with science budgets; perhaps keeping up with inflation.

Thank You!

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