



Bipartisan Policy Center



Center for a
New American
Security

Cementing American Artificial Intelligence Leadership: AI Research & Development

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I. Lead in Research & Development

Greater investments in artificial intelligence research and development are essential to maintaining American leadership in AI. Throughout the 20th century, the federal government played a critical role in fueling technological innovation by funding pivotal basic research. Government funding was essential to developing the transistor, GPS, and the internet—inventions that transformed the world economy. Yet over the past several decades, federal government spending on R&D as a percentage of GDP declined from about 1.2% in 1976 to around 0.7% in 2018.¹ This is a worrisome trend as the federal government remains the main funder of basic research. Government support again could be pivotal both in fostering new AI breakthroughs and ensuring that the U.S. government has access to those breakthroughs.

Beyond AI, overall R&D spending trends are troubling. Other countries are outpacing the United States with faster growth of their national R&D budgets. Total U.S. national (public and private) R&D expenditures as a share of GDP have been mostly stagnant since 1996. China quadrupled its R&D expenses as a share of GDP over the same time frame, and countries like Israel and

South Korea also significantly ramped up spending.² As a result, the U.S. share of global R&D has declined over the past several decades, falling from 69% in 1960 to 28% in 2016. From 2000 to 2015, the United States accounted for 19% of global R&D growth, while China accounted for 31%.³ China was on track to top the United States in total R&D investments (in purchasing power parity-adjusted dollars) as soon as 2019.⁴

R&D is a key driver of long-term economic growth. According to a report from BPC's American Energy Innovation Council titled *Energy Innovation Fueling America's Economic Engine*:⁵

TECHNOLOGICAL INNOVATION CAN IMPROVE PRODUCTIVITY ACROSS INDUSTRIES AND CREATE ENTIRELY NEW ONES. THIS IS ONE AMONG MANY REASONS WHY ECONOMISTS AGREE THAT INNOVATION IS A DRIVER OF LONG-TERM ECONOMIC GROWTH AND STABILITY—AND WHY AT LEAST 50 PERCENT OF U.S. ANNUAL GDP GROWTH CAN BE TRACED TO INCREASES IN INNOVATION.

The Bipartisan Policy Center (BPC) and the Center for New American Security (CNAS), in consultation with Reps. Will Hurd (R-TX) and Robin Kelly (D-IL), have worked with government officials, industry representatives, civil society advocates, and academics to better understand the country's major AI related R&D needs. This paper hopes to shed more clarity on these challenges and provide actionable policy recommendations, to help guide a U.S. national strategy for AI. BPC's effort is primarily designed to complement the work done by the Obama and Trump administrations, including President Barack Obama's 2016 *National Artificial Intelligence Research and Development Strategic Plan*⁶ and President Donald Trump's 2019 update, Trump's Executive Order 13859, announcing the *American AI Initiative*,⁷ and the Office of Management and Budget's subsequent *Guidance for Regulation of Artificial Intelligence Applications*.⁸ The effort is also designed to further advance work done by Kelly and Hurd in their 2018 Oversight and Government Reform Committee (Information Technology Subcommittee) white paper *Rise of the Machines: Artificial Intelligence and its Growing Impact on U.S. Policy*⁹ and the CNAS report *The American AI Century: A Blueprint for Action*. Our goal through this effort is to provide the legislative branch with actions it can take to advance AI building on the work being done by the Obama and Trump administrations.

II. Key Principles

1. Overall federal AI R&D spending needs to increase significantly
2. The country needs to expand and diversify its computing capacity
3. The federal government plays a key role in incentivizing private sector R&D
4. There needs to be international cooperation to advance AI research and development
5. The federal government would benefit from opening up avenues for private talent
6. AI standards and measurement are essential to fostering AI technologies that are safe, secure, reliable, and comport with U.S. norms and values

III. Overview

The private sector, academia, and the government have a long history of collaborating to advance technological innovation. Academia, often through support of federally funded grants, historically has conducted much of the basic research that has enabled the private sector to advance applied research and commercialize technologies. This partnership, however, is being strained by recent innovations in machine learning whose advancement relies on large datasets and compute resources that are increasingly unavailable to academic researchers. To ensure the United States is maximizing its R&D potential and to ensure the entire R&D cycle from basic research to commercialization is fully utilized, the partnership of government, academia, and the private sector must be strengthened to ensure each has adequate access to the resources they need while protecting intellectual property rights and data privacy.

This includes standardizing and making current and future government datasets more readily available to the private sector and academia to facilitate training of machine learning models.¹⁰ Under the OPEN Government Data Act of 2019, federal agencies are required by statute to make available government datasets in standardized, machine-readable formats.¹¹ Doing so will help to address data scarcity problems, especially for entities with significant resource constraints such as startups or some university researchers, by expanding the number of open-source high-quality datasets and increasing access to compute resources.¹²

IV. Key Takeaways

Overall AI R&D spending needs to increase significantly

The U.S. government remains the largest funder of basic research in the United States. As during the 1960s and 1970s, government support again could be pivotal today both in fostering new breakthroughs and ensuring that the U.S. government has access to them. The federal government should prioritize high-risk/high-reward basic science research—areas where private industry has little incentive to invest but that holds tremendous potential for valuable new knowledge. Breakthroughs in software, such as novel AI techniques that address the limitation of existing AI methods, and hardware, such as next-generation semiconductor technologies and superconducting artificial neurons, could be game changers that provide the United States with a continuing technological edge. Advances in AI can also further R&D of other fields because of its broad, interdisciplinary nature, while breakthroughs in areas like neuroscience can greatly advance AI development.

Unclassified federal government spending on defense AI R&D in fiscal year 2020 will be about \$4 billion, according to a Bloomberg analysis from March 2019.¹³ In September 2019, the White House announced an FY2020 non-defense AI R&D budget request of nearly \$1 billion.¹⁴

In contrast, the level of Chinese government spending on AI R&D is not clear. Complete annualized figures for Chinese government spending are not publicly available. Instead, only announcements of planned, multi-year spending offer a window into the scale of overall government R&D spending at the national, provincial, and local levels.¹⁵ For instance, two Chinese cities alone announced the creation of RMB 100 billion (approximately \$15 billion) multi-year AI development funds while Beijing unveiled plans for a \$2 billion AI research park in 2018.¹⁶

The United States enjoys robust private sector R&D funding. Precise figures are hard to discern because companies typically do not divulge details for R&D expenditures in their financial statements and privately-owned firms do not have such reporting requirements. That said, looking at overall R&D expenditures by major AI-intensive companies gives a sense of the scale of private investments in AI R&D. The combined 2018 R&D expenditures by U.S. firms Alphabet, IBM, Facebook, Microsoft, and Amazon was \$80.5 billion.¹⁷

China's tech giants also report significant R&D investments, although they are considerably smaller than those of their U.S. counterparts. Leading Chinese AI firms Alibaba, Baidu, and Tencent collectively spent \$9.1 billion on R&D in 2018.¹⁸ These firms are also major investors in Chinese AI startups.¹⁹

In April 2020, the National Security Commission on Artificial Intelligence (NSCAI) published its first quarter recommendations, calling for an immediate doubling of non-DOD AI R&D funding to \$2 billion. NSCAI emphasized the importance of funding basic research and investing in new microelectronics technologies. This echoes the White House AI R&D budget request for FY2021-22.²⁰

Recommendation #1: Congress and the White House should adopt the NSCAI and White House recommendations to double AI R&D spending immediately, and further commit to boosting total yearly federal AI R&D spending to \$25 billion by FY2025. Spending at this level is realistic and doable: \$25 billion is equal to about 19% of total federal R&D spending in the FY2020 budget. Congress should concurrently raise total federal R&D spending to 1.2% of GDP to achieve an overall boost of total public and private R&D spending to 4% of GDP.

Recommendation #2: Congress should ensure R&D includes funding to address shortcomings of current AI methods with novel fundamental approaches: prevalent deep learning systems in use today typically require large amounts of training data and computing resources that are often not available to academics and startups. Research of novel AI techniques requiring smaller data sets to train and that make more efficient use of compute could lead to important breakthroughs in the field.

While increased investments in AI R&D are urgently necessary, this should not come at the expense of research in other disciplines. American competitiveness in the 21st century will depend on strong capabilities in a broad range of capabilities. Importantly, R&D investments in other sectors can enable better AI systems, creating a virtuous cycle of scientific advancement.

The country needs to expand and diversify its computing capacity

AI systems require computational power (commonly called “compute”) to run. Access to large amounts of compute fundamentally changes what kinds of research an AI project can undertake. The U.S. government has ongoing efforts to create compute infrastructure for research. To support research, the White House’s American AI Initiative directs federal agencies to allocate compute resources for AI applications and R&D.

A number of U.S. government supercomputers built for AI applications, like the Department of Energy’s Center for Accelerated Application Readiness, have opened applications to the public for research projects. For hardware development, the National Science Foundation has jointly funded projects, for instance with the Defense Advanced Research Projects Agency (DARPA), to develop next-generation chips.

Another precious resource is data. Data scarcity is a common barrier to entry for AI researchers at universities and startups. The Trump administration's AI Executive Order proposes to standardize government data and make current and future government datasets more readily available to the private sector and academia to facilitate training of machine learning models. Further, the government's Project Open Data is a major step in making data discoverable and usable.

The pandemic crisis demonstrated the need for and the ease by which compute resources and valuable datasets can be made available. The Department of Energy, National Science Foundation, and NASA are helping to lead an international effort which is bringing together the federal government, industry, and academic leaders to provide access to the world's most powerful high-performance computing resources in support of COVID-19 research. In March 2020, the White House Office of Science and Technology Policy spearheaded an effort to produce the COVID-19 Open Research Dataset (CORD-19) with partners in academia and private industry. This comes on the heels of other data-sharing initiatives in industry and civil society.

On 29 March 2020, the Human-Centered AI Institute at Stanford University and 22 presidents and provosts of the United States' leading computer science universities called for a U.S. government-led task force to establish a National Research Cloud. Its goal is to "provide academic researchers with affordable access to high-end computational resources, to large-scale government-held datasets in a secure cloud environment, and to the necessary expertise to benefit from this resource."²¹

Recommendation #3: Congress should convene this proposed task force, or a similar one, to establish a National Compute and Data Resource. Pooling government-owned and -funded compute and data resources has the potential to unleash a new wave of technological advances. Making computing resources readily available is critically important: the amount of compute required for AI training runs is increasing exponentially, and compute is essential to progress in AI development.

There is an inconsistency in availability of AI resources across the country. A key driver is the lack of broadband in rural areas. According to recent data from the Federal Communications Commission, over 19 million Americans living in rural areas do not have access to fixed terrestrial broadband providers.²² Additionally, computing power is expensive and limited in accessibility, making it difficult for many public and private sector researchers to remain competitive in a rapidly evolving field. Making cloud computing more widely available opens up the potential for cutting-edge R&D to take place outside America's current AI hubs, making many small and mid-sized cities more appealing locations for startups and their employees. Several efforts are underway to help address this. In Massachusetts, a number of top universities partnered with the state

government and the private sector to establish the Massachusetts Green HighPerformance Computing Center, which houses a number of high-end computer systems available to researchers. State and federal agencies partnered to build the infrastructure necessary to support the center. Additionally, the project benefited from the federal New Markets Tax Credit Program that promotes private capital investment in low-income regions.

Recommendation #4: Congress should address the need to expand broadband into rural areas.

Recommendation #5: Congress should create a competitive grant program for universities to develop clusters of affordable graphics processing units (GPUs) and high-performance computers that are accessible to rural and underserved areas. Improved digital infrastructure across the United States would help to create new job opportunities and stimulate growth of new tech and innovation clusters.

Recommendation #6: The Department of Energy should expand opportunities for academics and researchers to access computational resources available through national supercomputing labs.

Recommendation #7: Data resulting from federally funded grants should, to the maximum extent possible, be made publicly available in accordance with appropriate safeguards to protect personally identifiable information.

The federal government plays a key role in incentivizing private sector R&D

America's private sector has a key comparative advantage in sustaining overall AI leadership by the United States. Policymakers have several ways to stimulate further R&D activity by corporations while adhering to free market principles.

Recommendation #8: The Senate Finance and House Ways and Means Committees should hold a hearing or series of hearings to explore how to further incentivize R&D through the tax code. Some possible options could include:

- Accelerated depreciation of qualifying R&D assets for small market cap or companies building in economic opportunity zones to encourage more frequent investments in, and upgrades to, R&D assets such as labs and equipment. Importantly, IRS would need to establish anti-abuse rules to prevent improper use of the depreciation.
- If the current R&D tax credit cannot be meaningfully enhanced, consider a R&D expenses super-deduction tax incentive which would promote increased R&D spending by corporations.
- Cash grants and low interest loans to provide capital to entities pursuing high-risk/high-reward research, which often face barriers to obtaining

funding.

- Tax exemptions and reductions for qualified tech transfer to promote cross-industry technology diffusion and spin-off company creation to boost innovation.
- Patent-related incentives for small cap companies, such as reduced tax rates on income from intangible assets to promote R&D of intangible assets, which often have a longer development timeline and a higher risk of failure. Many other countries—notably in Europe—have generous R&D tax incentives, including credits and deductions, as well as “knowledge boxes” or “patent boxes” that have attractive rates for patents earned from R&D and innovation conducted in-country. The United States should continue to consider such incentives, along with making the current R&D tax credit more robust.

There needs to be international cooperation to advance AI research and development

As an open democratic society with world-class universities, research institutes, and corporations, the United States makes for an attractive partner in joint R&D. Decades of experience show that joint work with foreign researchers can be done with great benefit and little detriment to our economic and national security.²³ In February 2019, President Trump issued Executive Order 13859 which included an emphasis on the importance of collaborating with international partners.

The benefits of international collaboration include cost sharing; aligning complementary knowledge, experience, and know-how; improved interoperability; developing norms and principles; and more efficient standards setting. The United States joining the Organisation for Economic Cooperation and Development in adopting global AI principles was an important step in the right direction because it shows U.S. support for international norms in developing trustworthy AI. This helps foster global cooperation and promotes values such as human rights.

The United States is fortunate to have most of the world’s leading AI powers as allies and partners. The United Kingdom, France, Japan, Singapore, and South Korea, for example, have committed hundreds of millions of dollars to AI R&D. Toronto is a global AI hub. Each of these locales, and numerous others, are prime candidates for mutually beneficial cooperation. Global AI issues—ensuring AI is safe, transparent, explainable, reliable, and resilient—are especially well suited to broad international research cooperation. The United States is in an especially strong position to foster multilateral cooperation on defense and security-related applications for AI.

Recommendation #9: To promote allied cooperation on national security related-AI, Congress, the White House, and the Secretary of Defense should adopt NSCAI's Q1 recommendations to expand and institutionalize AI-enabled warfighting and intelligence efforts. This includes creating a National Security Point of Contact and aligning AI adoption efforts starting with the Five Eyes partners.

Recommendation #10: To promote multinational collaboration on AI R&D, the White House Office of Science and Technology Policy, in conjunction with Congress, should:

- Organize and fund multinational innovation prize competitions. Such competitions could be modeled on DARPA's series of Challenges and the XPRIZE competitions, which have successfully tackled some of the toughest science and engineering problems, including in AI.
- Identify and fund opportunities for grants and loans to facilitate international personnel exchanges. Multilateral collaboration on AI would be particularly fruitful in areas such as AI safety and disease outbreak modeling.

Recommendation #11: The National Science Foundation should work with science funding organizations in allied countries to establish multilateral teams of AI researchers from the public and private sectors to promote talent development and foster partnerships on AI R&D.

The federal government would benefit from opening up avenues for private talent²⁴

As with any company today, the federal government needs tech expertise. Agencies are increasingly using data to administer benefits, assess outcomes, and fulfill other mission-critical activities. Unfortunately, as has been well-documented, the federal hiring process is overwhelmingly complicated and hinders the ability of agencies to quickly hire the tech experts they need. Furthermore, like academia, the government cannot compete with the private sector in terms of salaries. However, like academia, it can provide workers with opportunities not seen in private R&D including making public policy, experimenting in novel fields that are unrelated to the need to commercialize a technology and the opportunity to serve the public good.

Additionally, the federal government needs tech experts to effectively create, manage, and implement AI-related R&D grants. To bring more tech expertise into the federal government, employment processes should be addressed through the creation of fellowship programs, inefficiencies in the hiring process, and enable tech experts to float between agencies.

Recommendation #12: Amend the Intergovernmental Personnel Mobility Act to make it easier to recruit tech people into government service from

academia and state and local governments as well as to move tech experts between agencies.

Recommendation #13: Expand and replicate programs like the U.S. Digital Services, which places technologists in a variety of projects and agencies, and the Department of Defense’s Cyber Excepted Services, which has cut hiring times in half for new employees.

AI standards and measurement are essential to fostering AI technologies that are safe, secure, reliable, and comport with U.S. norms and values

AI should be safe, reliable, secure, and resilient. Standardization of AI techniques can help to define these qualities and provide a potential foundation for developing metrics or measurement instruments and inform any decision regarding regulation. The United States has long been a leader in standards-setting, such as in telecommunications. U.S. leadership in global AI standards-setting will help ensure that AI implementations play to our strengths and comport with our interests and values.

In August 2019, the National Institute of Standards and Technology (NIST), part of the Department of Commerce, published a plan for how federal agencies should engage in AI standards. This leadership role was mandated by the Trump administration’s American AI Initiative. Outside of the U.S. government, the American National Standards Institute (ANSI) is one of the leading national organizations focused on standards-setting both in the United States and abroad. A subgroup within ANSI, the International Committee for Information Technology Standards, is working specifically on developing standards in AI. Working groups now are debating such topics as trustworthiness in AI, big data, AI use cases and applications, and governance implications of AI.

Measuring AI

Measurement is how the AI research community orients itself and prioritizes research. Some measurement-focused initiatives, like the “ImageNet competition,” have helped define field-wide progress in areas such as image recognition. Other initiatives, like New York University’s language-focused “GLUE” benchmark, have themselves become catalysts for further research. After various people submitted AI systems that maxed-out performance on GLUE, NYU built a new, harder benchmark called “SuperGLUE,” which is serving to further catalyze progress.

Benchmark tests are necessary to understand the performance of an AI system. With the breadth of technologies, functions, and capabilities that comprise AI, devising quantitative measurement schema poses a challenge. As a result, current tests for measuring AI range from vague and conceptual to well defined

and mature. The AI Index has compiled some of the best examples of efforts to track progress of AI research.

An example from the established end of the AI research spectrum is the F1 score—a function of precision and recall—that is used widely to evaluate natural language processing models. On the other end of the spectrum is the concept of computational creativity, the ability of a computer to create new ideas from existing information or to solve a problem it has not encountered before. Scientists still argue over what “creativity” means or whether it is possible for computers, let alone how to measure it.

Moreover, AI measurement methodologies are not static. As technologies mature, and expectations of machine intelligence change, many tests that make sense today will not be as relevant a few years from now. Periodic reexaminations and updates of testing methodologies will be necessary to ensure that AI systems are functioning optimally.

Take the example of the stalwart Turing Test, often used to test how well chatbots can mimic humans. Over half a century old, it is less meaningful today as a means to measure machine intelligence. Experts have proposed new tests of artificial creativity and intelligence such as Lovelace 2.0 and Winograd Schema Challenge as alternatives to Turing. Winograd itself has shortcomings due to language- and data-based biases, according to a group of researchers. In July 2019, researchers announced a new, much larger challenge and associated dataset called WINOGRANDE that addresses these deficiencies.²⁵ We should expect further improvements to this new schema as knowledge and capabilities grow.

U.S. government involvement in standards-setting and measurement is important because policymakers will have direct access to the quantitative information needed for better, evidence-based decision making. It further helps government experts identify areas where targeted grants—such as academic research on quantifying AI “robustness” and “trustworthiness”—would help to establish well-defined and effective metrics.

Recommendation #14: The White House Office of Science and Technology Policy should establish an NSTC Subcommittee for AI Standards & Measurement. Co-chaired by OSTP and NIST, the subcommittee would be created under the existing NSTC Select Committee on AI, whose mandate is to “prioritize and promote AI R&D, leverage federal data and computing resources for the AI community, and train the AI-ready workforce.”

Conclusion

The United States has long been a leader in R&D, but that prominence is slowly being eroded as other countries increase their R&D investments, and find other ways to further incentivize R&D. A critical area for R&D is around emergent AI technologies, such as those that address the limitations of deep learning. To ensure the United States remains a leader in technology, it must find ways to better incentivize and invest more in R&D, promote more collaboration among businesses, university, and government to share resources, and ensure we have adequate researchers available to each sector.

Endnotes

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