U.S. AI Policy Report Card

By Hodan Omaar | July 27, 2022

Policy discourse on artificial intelligence (AI) in the United States is at an all-time high. The 117th Congress was the most AI-focused congressional session in history with 130 AI bills proposed in 2021 compared with just 1 in 2015.[1] Given this high level of interest from lawmakers, it is a good moment to take stock of the accomplishments of U.S. AI policy to date, as well as areas where there is room for continued progress toward U.S. leadership in this space.

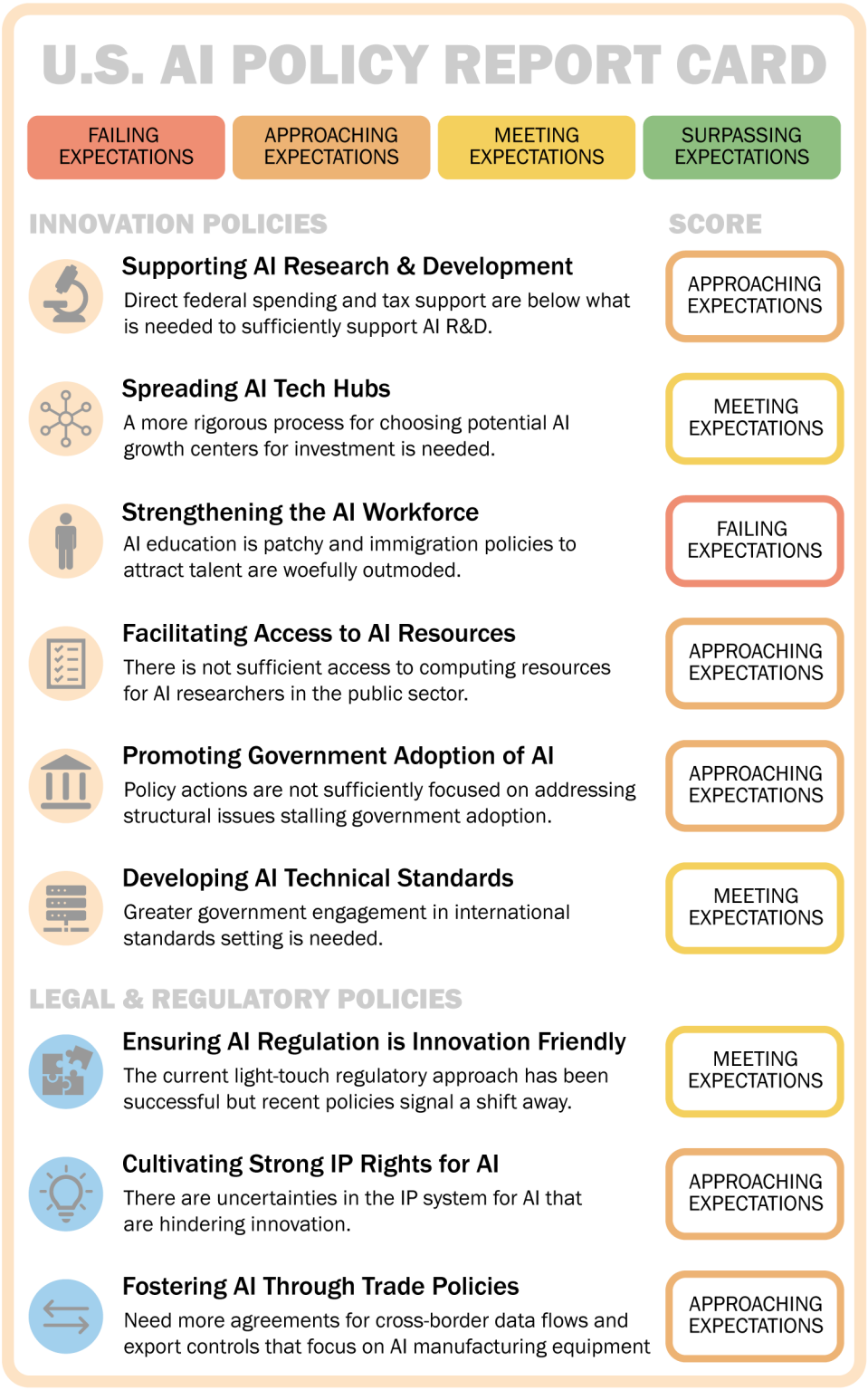
EXECUTIVE SUMMARY

In the United States, there are three sets of institutions that are primarily responsible for initiating, importing, modifying, and diffusing AI: private firms, publicly funded national laboratories, and universities with funding from government, industry, and donors. AI policy refers to the public means for nurturing the capabilities and activities of this AI ecosystem and optimizing its applications in the service of national goals and the public good. When government institutions and policies act properly, AI innovation flourishes. When government fails to act or misfires, so too does AI innovation.[2]

This report analyzes how the United States is performing across nine of the most prominent policies the U.S. government uses to support AI innovation and competitiveness. We split these policies into two groups. First are innovation policies that directly spur AI innovation and competitiveness. These include six types of policies that support AI research, strengthen the AI workforce, spread AI tech hubs across the country, facilitate access to AI resources, promote government adoption of AI, and help develop technical standards for AI. Second are legal and regulatory policies that shape the environment for AI innovation. These include three types of policies that regulate the use of AI systems, incentivize AI activity through intellectual property (IP) rights, and support AI development through international trade.

The following report card summarizes our findings for each policy area and provides an achievement level. To be failing expectations in a policy area means the policies in place—or lack thereof—are causing the United States to fall behind its competitors. To be approaching expectations means the policies in place are only partially or inconsistently bolstering U.S. AI innovation and competitiveness. To be meeting expectations means the

policies in place are keeping the nation on par with its competitors. And to be surpassing expectations means the policies in place are properly supporting U.S. AI leadership. In the following sections, we provide detailed recommendations for how U.S. policymakers can improve.



AI INNOVATION POLICIES

SUPPORTING AI RESEARCH & DEVELOPMENT

Overall grade: Approaching expectations

Reason: Current levels of direct federal AI spending and tax support are below what is needed to sufficiently support AI R&D at levels keep the country competitive.

DIRECT AI R&D SPENDING

Robust federal research and development (R&D) investment is needed to advance AI for two main reasons. First, to make up for the fact that the private sector invests less than societally optimal levels in AI research because they are almost never able to capture all the spillover benefits of their initial investment, or capture these benefits fast enough, to justify investing at the same level as the government. The knowledge they create spills over into the knowledge commons and competitors are able to capitalize on it. This is especially true in the case of basic research, which is more costly and riskier than applied R&D.[3] Second, the private sector tends to narrowly focus its research on only the AI fields that are commercially relevant and economically beneficial, rather than on all those that might advance the public good. To see this, consider that only 18 percent of the AI algorithms in use today originated from the private sector, according to a 2020 study by researchers at the Massachusetts Institute of Technology and the University of Pennsylvania.[4] The other 82 percent originated from research at federally funded institutions.

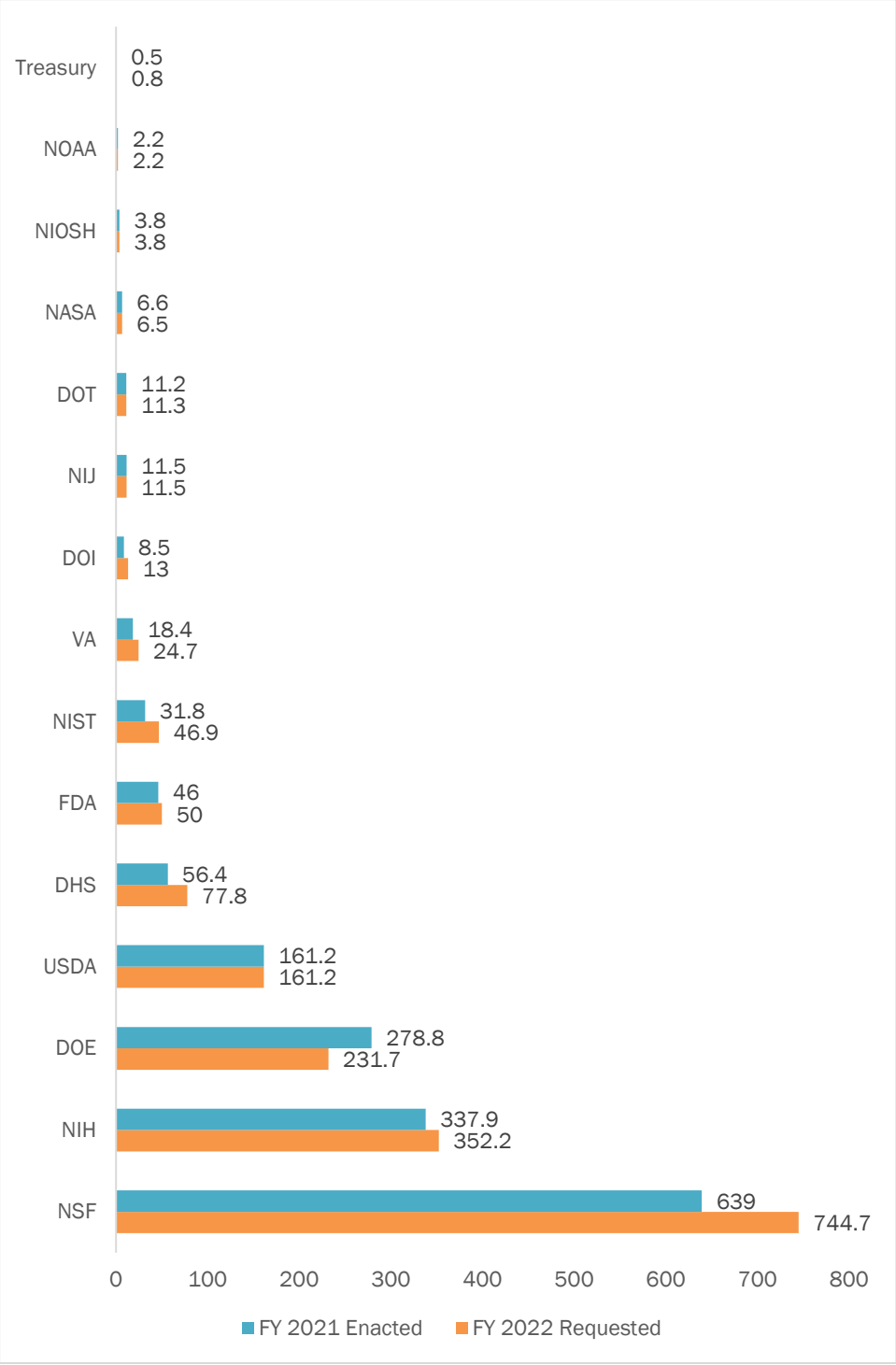
The Obama administration was the first to commission a federal strategy to guide federal investment in AI R&D, which the Networking and Information Technology Research and Development (NITRD) subcommittee published in October 2016. Called the *National AI R&D Strategic Plan*, it outlined seven strategies to help guide the overall portfolio of federal investments:

- Make long-term investments in AI research
- Develop effective methods for human-AI collaboration
- Understand and address the ethical, legal, and societal implications of AI
- Ensure the safety and security of AI systems
- Develop shared public datasets and environments for AI training and testing
- Measure and evaluate AI technologies through standards and benchmarks
- Better understand the national AI R&D workforce needs[5]

The Trump administration updated the plan in 2019 with an eighth strategy to expand public-private partnerships to accelerate advances in AI and imbued the existing plan with a stronger focus on maintaining U.S. leadership.[6]

While NITRD's AI R&D Strategic Plan provides a national framework for AI R&D priorities, it does not direct policy or funding. Instead, the president and Congress set nondefense AI R&D priorities and funding for each federal agency through an annual fiscal year budget, with defense spending set through a separate bill called the National Defense Authorization Act (NDAA). Figure 2 shows a breakdown of the Biden administration's budget request for nondefense AI R&D in FY 2022 and the amount enacted in FY 2021. In total, funding for nondefense AI R&D increased from around $1.6 billion to $1.7 billion.

Figure 1: AI R&D investment (in millions of dollars)[7]



The Biden administration has been pushing for even more AI R&D, identifying AI as one of the breakthrough technologies in line for increased federal investment over the next four years. The administration's budget request for FY 2022 includes a little more than $1.7 billion, which includes funding for federal agencies to create a national network of AI research centers, as Congress directed in the National AI Initiative Act of 2020.[8] The administration announced its budget request for FY 2023 in March 2022, indicating it will request even more funding for major investments in AI. For instance, the budget includes a request for $187 million for the National Institute of Standards and Technology (NIST) to expand research initiatives focused on accelerating AI adoption through technical standards development.[9] Additionally, the Senate passed the U.S. Innovation and Competition Act (USICA) in 2021, which includes a proposal to create a new National Science Foundation (NSF) directorate focused on technology and innovation. The Senate's bill would authorize $9.3 billion for the directorate by FY 2026 to strengthen the leadership of the United States in a range of critical technologies, not just AI.[10]

The question becomes, How much federal AI R&D funding is enough to accelerate AI innovation and keep the nation competitive? According to the National Security Commission on AI (NSCAI), an independent commission established by Congress in 2018 to review the steps the United States needs to take to advance AI development, the United States should be doubling investments in nondefense AI R&D annually from the baseline of $1 billion in FY 2020 in order to reach $32 billion in FY 2026, which would bring federal AI spending to a level on par with biomedical research.[11] Federal funding should therefore be at least $2 billion in FY 2022 and increase to $4 billion in the FY 2023 budget.

To improve the overall effectiveness and productivity of federal AI R&D, the National AI Initiative Act of 2020 also established an agency called the National AI Initiative Office (NAIIO) within the Office of Science and Technology Policy (OSTP) to coordinate federal support for AI R&D, education and training, and research infrastructure. The office is still new, and how effective it will be at coordinating federal AI R&D activities remains to be seen.

Recommendations for improvement:

- **Congress should increase AI R&D funding in FY 2023 to at least $4 billion.** The Senate's proposed funding of $9.3 billion by FY 2026 for a new NSF directorate would get the United States part of the way to this goal if this provision is included in the final competitiveness legislation both chambers of Congress are working to bring across the finish line. But to ensure the United States is on track to reach funding levels that keep the nation competitive in AI specifically and across agencies, Congress should increase overall AI R&D funding to $4 billion in FY 2023.

- **NITRD should update the National AI R&D Strategic Plan to include measuring and monitoring the capabilities of AI systems.** Today, it is

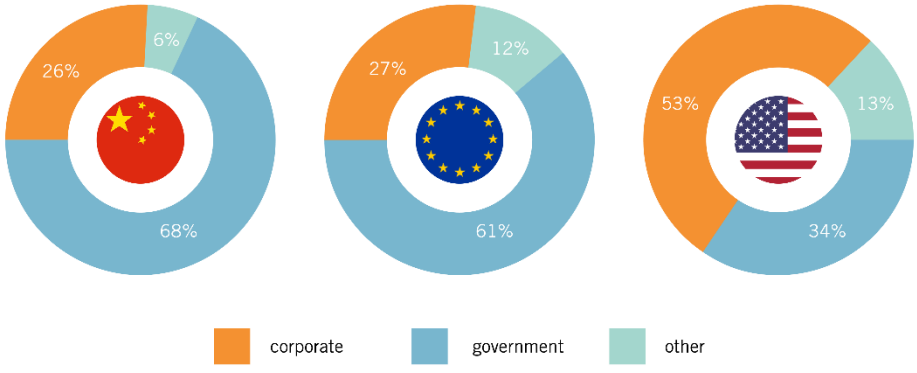
difficult for policymakers to identify the specific needs and priorities of the research community because government lacks the capacity and infrastructure to systematically measure and monitor the capabilities of the AI ecosystem.[12] Investing in better metrics would enable policymakers to better identify where research could support policy needs.

R&D TAX CREDIT

Economists have shown that the R&D tax credit, which provides a tax break for companies incurring R&D costs, is an effective tool to encourage private companies to invest in R&D. Importantly, studies of R&D incentives show that they not only spur firms to do more R&D than they would otherwise do, but also lead to more of that R&D to be performed in the jurisdictions with the incentives.[13]

Stimulating private investment in AI R&D is crucial to cementing U.S. leadership in AI because the private sector in the United States plays a uniquely important role in conducting AI R&D.[14] Consider the findings from Stanford University's 2021 AI Index report on R&D activities around the world. The report finds that the highest proportion of peer-reviewed AI papers in every major nation come from academic institutions, but the United States is distinct in that the second most important originators come from industry, with corporate-affiliated research representing 19.2 percent of the total publications (figure 1).[15] By contrast, government is the second most important in China (15.6 percent) and the European Union (17.2 percent).

Figure 2: The biggest AI R&D originators, excluding academia, in China, the EU, and the United States



Unfortunately, tax incentives in the United States for R&D are quite minimal. The country ranks 32nd out of 34 comparable Organization for Economic Cooperation and Development (OECD) and BRIC (Brazil, Russia, India, and China) nations, having slipped from 24th place in 2020.[16] As of 2022, a provision in the 2017 Tax Cuts and Jobs Act (TCJA) no longer allows companies to expense current R&D costs in the first year (to deduct the costs of R&D from their taxable income in the year they incur those costs) and instead requires costs to be amortized over a period of five years, effectively reducing the R&D subsidy by about 5 percentage points, from around 9 percent to 4 percent.[17]

This change reduces the U.S. comparative advantage in all innovation-based industries. But because the private sector plays a unique role in AI R&D compared with other countries, the impact on AI competitiveness is outsized.

Fortunately, the Biden administration has indicated support for enhancing tax incentives for R&D. In response to a question from Senator Todd Young (R-IN) about maintaining the immediate deductibility of R&D expenses, U.S. Treasury Secretary Janet Yellen said:

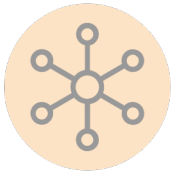
> [P]romoting innovation is a critical priority for President Biden, and it is a very important contributor to productivity growth in this country. And we're absolutely looking for ways to do that, and certainly continuing to allow firms to expense R&D rather than shifting to amortizing could be one very effective way to bring that about. There could also be more generous R&D tax credits. There might be other approaches, but many OECD countries do permit expensing of R&D. So this is something we certainly would want to work with you on and find a way to be supportive of more tax support for R&D.[18]

Recommendations for improvement:

- **Congress should lift the overall R&D subsidy rate to levels on par with comparable countries to better incentivize private sector AI R&D.** As the Information Technology and Innovation Foundation (ITIF) explained in its 2020 report *Enhanced Tax Incentives for R&D Would Make Americans Richer*, a fiscally responsible target would be to increase the overall subsidy rate to at least 15.5 percent from 9.5 percent. This target could be reached by increasing the rates for the two main investment tax credits the government uses (the Regular Credit and the Alternative Simplified Credit) to 43.5 percent and 30.5 percent, respectively.[19]

- **Congress should broaden and expand the R&D credit for collaborative research.** The United States provides a 20 percent tax credit for collaborative R&D to encourage private sector investment in research conducted at universities, federal laboratories, and research consortia. But it only applies to energy research. Congress should eliminate the energy restriction to support collaborative research in other research areas, including AI.[20]

SPREADING AI TECH HUBS



Overall grade: Meeting expectations

Reason: The government could take a more rigorous approach to better choose the most promising potential AI growth centers for investment.

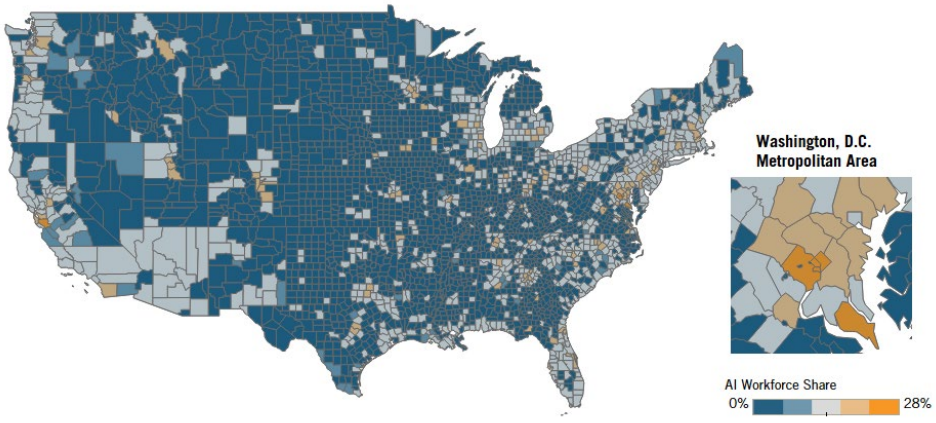
Many innovation and competitiveness scholars point out that America's most innovative firms frequently cluster together in small, relatively well-defined regions.[21] Innovation clusters offer several benefits for the AI industry. For one, in the early stages of technology development, clusters tend to produce and exchange industrial "gossip" about production processes that helps

nearby firms be more competitive and productive while distant firms either never receive this information or hear about it too late.[22] For another, industry clusters can create efficient markets for inputs that are specific to an industry. For example, manufacturers of customized AI chips want to be as close to as many AI companies as possible because outside of AI system production, there is little market for their products.

The problem is, while the clustering of AI skills and firms promotes innovation and growth within regions, hyperconcentration of the associated economic gains may further entrench the already imbalanced geography of the nation's economy. As ITIF explained in *The Case for Growth Centers*, the innovation sector has generated significant technology gains and wealth but has also helped spawn a growing gap between the nation's dynamic "superstar" metropolitan areas and most everywhere else.[23] Among the superstar metro areas, the "winner take most" dynamics of the innovation economy have led to dominance, but also to livability and competitiveness crises: spiraling real estate costs, traffic gridlock, and increasingly uncompetitive wage and salary costs. Meanwhile, in many of the "left-behind places," the struggle to keep up has brought stagnation and frustration. These uneven realities represent a serious productivity, competitiveness, and equity problem.

Current AI activity in the United States is clustered around these existing superstar tech hubs. Indeed, figure 4 shows that the AI employment is highest in big tech hubs such as Austin, Boston, New York, the San Francisco Bay area, Seattle, and Washington, D.C. The graph also shows some less densely populated areas with higher shares of AI employment, such as in Colorado and New Mexico where there are U.S. national labs.[24]

Figure 3: U.S. employment share in AI is highest in major cities[25]



This is not surprising. AI is still an emerging technology, and the earliest stages of technology development are often spatially concentrated near the sites of key innovations.[26] However, without federal efforts to counter the self-reinforcing dynamics inherent to network-based systems such as the AI industry, it is unlikely the AI economy will become more geographically dispersed.

Fortunately, the federal government is in the midst of a new realization that national action will be necessary to counter the current concentration of AI investments in just a few geographic regions. NSF is leading the effort to create the national network of AI research centers mentioned earlier, and in 2021, it established 11 new AI research institutes with ties to 40 states, representing an investment of over $220 million and building on an earlier first round of institutes funded in 2020.[27] NSF together with OSTP is also planning to spread centers of AI excellence across the country as part of the implementation plan of a National AI Research Resource (NAIRR), which is envisioned as a shared computing and data infrastructure.[28]

As a 2021 Brookings report on the geography of AI notes, however, creating AI clusters in practice is a difficult task, and development strategies for regions should be realistic. There are at least 87 regions in the United States that have some AI research and commercialization capacities and are "potential AI adoption centers." But these regions vary widely in their starting points with different research sectors and business activities.[29] Policymakers should more comprehensively use data on their AI capacity and positioning to inform strategic decisions.

Recommendations for improvement:

- **NSF should coordinate selecting AI growth centers with the Department of Commerce (DOC), which Congress has directed to create a regional innovation hub program.** The Senate's USICA would provide $10 billion to DOC to establish and grow at least 20 regional technology hubs while the House's America COMPETES (Creating Opportunities for Manufacturing, Pre-Eminence in Technology and Economic Strength) Act authorizes $7 billion for at least 10 hubs. As NSF works to select the next most promising AI potential growth centers, it should coordinate its process for selection with DOC to ensure efforts are not duplicative and promising regions receive sufficient federal investment to make them successful.

STRENGTHENING THE AI WORKFORCE

Overall grade: Failing expectations

Reason: AI education is uneven in scope and depth while outmoded immigration policies are preventing much-needed foreign talent from contributing to U.S. AI innovation.

AI EDUCATION

Primary and Secondary AI Education

In the United States, the responsibility for primary and secondary education, including school financing, teaching credentials, and curricula fall on the states. Federal programs, including ones in the departments of Education, Agriculture, Health and Human Services, and Labor, also distribute billions of dollars in funding to address specific needs, such as low-income schools and child nutrition. Since states set their own educational priorities, the extent to

which schools implement curriculum standards that address AI varies across states and local school districts.

On one hand, this decentralized approach allows for greater creativity and innovation in how schools develop and implement AI curricula, potentially enabling an increase in the quality of education. But divergent approaches can exacerbate disparities in how rigorous curricula are and the qualifications of educators.[30] Indeed, integration of AI curricula in the United States is already uneven in both depth and scope. Many schools do not teach CS, which is seen as the first step in AI specialization.[31] Only 51 percent of U.S. high schools offer foundational CS and only 23 of the 50 states and District of Columbia require all high schools to offer CS.[32] The few schools that offer explicit AI courses also vary in the content and scope of their curricula. Consider the two U.S. public high schools with the most prominent AI curriculums: The North Carolina School of Science and Mathematics, a public, two-year boarding school that is administered by North Carolina's university system, received a $2 million gift to launch an AI program in 2018 to teach students how to use and create AI systems, with a strong focus on understanding the ethical implications associated with these technologies.[33] Seckinger High School, established with $79 million in funding by the Gwinnett County Public Schools district in Georgia, is incorporating AI courses in core subjects for its entire K-12 cohort.[34] Its program introduces elementary school students to block coding—a basic form of computer programming that uses visual instruction blocks to construct games—while middle and high school students can learn programming languages and apply robotics and sensors to real-world applications.[35]

An alternative to the U.S. approach is a more centralized, national government-mandated approach to AI education such as that of China, Korea, Bulgaria, and Kuwait.[36] In China, for instance, the Ministry of Education revised its national education requirements for high schools in January 2018 to officially include pedagogical content for AI in its information technology curricula. All high school students, from those in the most prestigious schools in Beijing to those in the hundreds of rural classrooms in China's outskirts, are required to complete an AI coursework module, which includes data encoding techniques; collecting, analyzing, and visualizing data; and learning and using a programming language to design simple algorithms, as part of a compulsory information technology course. [37] One pitfall of top-down approaches that mandate AI curricula, especially those with discrete AI curricula that have specific time allocations, textbooks, and resources, is that they can encourage students to engage in rote learning and discourage the type of independent and creative thinking that appears to play a supportive role in innovation and entrepreneurship. Germany has also mandated a national AI curriculum but is implementing a flexible integration mechanism that allows regions, school networks, and individual schools to decide whether the curriculum is embedded into other subject areas or delivered through out-of-school methods such as extracurricular activities.[38] These types of approaches may not be realistic within the realities of the U.S.

education system, but the federal government can play an important role in ensuring AI education is equitable and functions as effectively as possible.

While the U.S. school system has not fully responded to the increased importance of AI skills, more employers, parents, and even students recognize the benefits of learning AI. Several nonprofits and advocacy groups, learning-programs, and courses have sprung up in response. Nonprofits such as Girls in Artificial Intelligence and Technology Education (GAITway), AI4ALL, Black Girls Code, and Girls who Code seek to increase access to AI education across gender lines and socioeconomic divides, introduce AI to students at a younger age, train more teachers, and put AI into more schools. The private sector is also reinforcing AI integration in schools through a number of different initiatives ranging from after-school programs to hackathons to summer camps. A 2021 report finds that for-profit companies are responsible for hosting 59 percent of the close to 450 AI and AI-related summer camps that exist across the United States.[39] For example, iD Tech Camps is a summer computer camp held at more than 150 U.S. college campuses that offers AI and machine learning courses for 13 to 17 year olds.[40] Some of these programs target populations typically underrepresented in AI and CS, such as Microsoft's DigiGirlz High Tech Camps, which are multi-day tech programs for girls in middle and high school.[41] Other private sector initiatives support teachers in-classroom learning by providing resources that aid learning, such as Google's CS First curriculum, a virtual free-to-use CS curriculum for students ages 9 to 14.[42]

Higher AI Education

Unlike U.S. high schools, where AI and CS education is deemed subpar, some U.S. institutions of higher education boast strong AI programs, drawing students from around the world. Moreover, interest in studying AI and AI-related courses at U.S. universities is surging as the market for these skills soars.[43] But U.S. institutions are frequently unable to meet demand because too few universities are willing or able to sufficiently persuade the qualified professors they need to increase their faculties and offer more classes to students to pick working in academia over lucrative private sector jobs.[44] Moreover, many colleges and universities respond inadequately to "customer" demand because they are unwilling to reallocate resources for less in-demand academic programs to make budget space for more in-demand ones such as CS.

At the undergraduate level, very few universities offer specific AI majors. Carnegie Mellon University's School of Computer Science began offering an undergraduate AI degree to a maximum of 35 students each year beginning in 2018, but it was the first U.S. university to do so.[45] While most colleges and universities offer CS bachelor degrees with AI concentrations or specializations, it is these CS majors in colleges across the country, from major state universities to small private colleges, that are increasingly being chosen by students. Swarthmore College, a private liberal arts college in Pennsylvania, has resorted to using a lottery system to select which students may enroll in CS classes—and in 2019, it implemented caps on the number of courses students may take in response to consistent "high enrollment

pressures." It had hoped it could allay placing restrictions on entry with "more faculty lines for the department or an abatement of increasing enrollments," but neither came to fruition.[46] The University of Maryland, a public research university facing similar pressures, made its CS program a limited enrollment major in 2019, meaning students must now complete a series of gateway courses before being admitted.[47] It also began instituting a differential pricing model for CS majors in 2015, along with engineering and business majors, charging students in these programs $5,600 more than their classmates for a four-year degree.[48] Increasing the cost of CS tuition allows the university to reduce demand by leading some students who otherwise would major in CS, especially those who are financially disadvantaged, to turn to other fields and enables the college to expand its CS programs by hiring more professors and introducing more minors.[49] But barriers like caps and weed-out classes often exacerbate gender and racial disparities in AI and CS.[50] A better solution would be for the state of Maryland to provide more funding for CS education, while at the same time for the university to reallocate resources from lower to higher priority programs. Doing so could prove difficult in practice, however, due in large part to internal institutional resistance. Consider data from the National Center for Education Statistics, which shows that the number of bachelor's degrees conferred in social sciences and history decreased by 7 percent between 2009 and 2018 while those in CS increased by 124 percent.[51] Reallocating resources to support more CS courses means taking resources from social science and humanities courses, and as Stanford economist Paul Romer noted, a "university that has fixed investment in faculty who teach in areas outside of the sciences and that faces internal political pressures to maintain the relative sizes of different departments may respond to this pressure by making it more difficult for students to complete a degree in science."[52]

It is clear that educational institutions do not adequately respond to market signals. As a result, it is incumbent on states and the federal government to require or incentivize tertiary education institutions to expand their ability to train a broader group of students in AI and CS. Many federal agencies are also prioritizing investment in AI higher education. For example, the 2021 National Defense Authorization Act directs NSF to fund AI initiatives for higher education (e.g., fellowships for faculty recruitment in AI) as well as AI curricula, certifications, and other adult learning and retraining programs.

The private sector has been playing a role in supporting tertiary AI education just as it does in primary and secondary education, providing everything from certificate and online learning programs to subsidized access to AI systems for teaching.[53] Perhaps no public-private AI partnership is as comprehensive as that of the University of Florida (UF) and Nvidia, a U.S. company that develops graphics chips. Anchored by a $25 million gift from UF alumnus and founder of Nvidia Chris Malachowsky, and an additional $25 million in hardware, software, training, and services from Nvidia, UF has launched an initiative to become an "AI University."[54] As part of this initiative, UF has incorporated AI into all undergraduate majors and graduate programs,

developed an undergraduate AI certificate program, and committed to hiring 100 faculty members in AI and applications.[55]

WORKFORCE TRAINING

Providing AI education is important, but national policy needs to also help incumbent workers. One problem impeding successful workforce policies is that while schools are primarily responsibility for equipping the future AI workforce with the requisite skills and knowledge they will need to succeed in an AI economy, there is little agreement about the respective responsibilities of individual workers, employers, and government in training the existing workforce.

Complicating matters is that there is no commonly agreed upon definition of what constitutes "AI expertise" or the "AI workforce," which means there is no common definition of a skills gap problem despite broad consensus that there is one. Indeed, existing literature on the AI labor market vastly disagrees on the pervasiveness, scale, and concentration of skills misalignments. As a 2019 report from the Center for Security and Emerging Technology (CSET) explains, there are many types of AI expertise one can include in a measure of the AI workforce, ranging from a top computer scientist who can lead an AI R&D team to an entry-level engineer who is not an AI specialist but has sufficient skills to execute coding tasks.[56] There are also many different domains of expertise; AI systems require hardware, software, and data, while successful AI teams need expertise in all three. In a subsequent report, CSET identified and measured the labor dynamics of four groups of AI workers that include those that provide technical inputs to AI applications, perform technical roles on an AI team, complement AI technical occupations in product development (e.g., legal compliance officers), and provide support for scaling, marketing, and acquisition of AI at the occupational level.[57] It finds that in 2019, the U.S. AI workforce consisted of 14 million workers, or about 9 percent of total U.S. employment. Moreover, it finds that there are divergent trends in these AI occupations, reflecting a difference in the supply and demand gap for different segments of the AI workforce. For example, the wage and employment growth of computer and information research scientists, which are small but important occupations within the AI workforce, is four times greater than the national average, while there is no notable gap for project management specialists and user experience designers.[58]

Where skills misalignments in AI jobs do exist, evidence suggests employers are investing in upskilling workers at suboptimal rates. Employer-provided training takes various forms, including formal and informal on-the-job training, tuition subsidies, classroom training, and apprenticeships. The composition and intensity of firm-provided training is hard to quantify as companies invest differently based on factors such as how much firm-specific training is needed to perform tasks effectively, the cost, and the extent to which they can share a portion of skill investment costs with workers (e.g., directly or in the form of lower wages). But research shows that few companies are investing substantially and examples of firm-provided AI-specific training are sporadic. According to a 2020 Deloitte report, only 18

percent of organizations around the world have significantly invested in AI-specific reskilling initiatives.[59] Still, private investments in the United States likely exceed federal government investment in training programs. Consider that Amazon invested $700 million in 2019 to retrain 100,000 employees, including by creating a "Machine Learning University." And Microsoft partnered with education provider General Assembly in the same year to upskill 15,000 workers in AI-related skills by 2022, while Shell has created AI courses that it offers to its range of employees, including petroleum engineers, chemists, and geophysicists.[60] As the primary federal workforce development program, the Workforce Innovation and Opportunity Act (WIOA), is funded at about $5 billion each year, private company investments are a key input to closing AI talent gaps.

It is unlikely that the rate of firms choosing to train employees will reach one that is optimal from a societal and economic perspective without government intervention. Corporate investment in workforce training in general has been on a downward trend as more and more firms seek to simply hire workers with the requisite skills instead of paying to train them.[61] After all, why would a company want to invest in training workers in costly AI skills when so many are leaving their jobs in record numbers?[62] The United States can work to reverse this trend by creating incentives for firms. One option is to allow qualified expenditures on workforce training to be taken as a knowledge tax credit. To ensure companies use this credit to focus on the skills of most of their workers, and not just managers, firms taking advantage of the credit could be required to abide by rules such as those for pension program distribution, which limit focus on highly compensated employees.[63]

The federal government could further improve workforce policies for AI by establishing wider use of skills credentialing so companies have a better way to assess the AI skills of prospective and current workers, and workers have a better way to identify and gain the AI skills they need to be successful. The idea of using AI credentials to provide alternative pathways to AI jobs is not a new one. In fact, AI certifications have proliferated over the past few years, with several large tech companies such as Google and Microsoft launching their own AI certifications, and many traditional online certification providers such as Udacity and Udemy offering AI-related certifications as well. The issue is that there is little market demand for these certifications in lieu of a four-year degree—even from the tech companies that make their own certifications. What's needed is a national approach and for the government to encourage the private sector to accept alternative certifications for AI, namely by accepting a suitable set as a substitute for a college degree when filling federal government jobs.[64]

Fortunately, the government has already begun to recognize the need for coordinated AI workforce policies at the national level. As part of the National Defense Authorization Act of 2021, Congress charged NAIIO with developing a strategic plan that establishes goals, priorities, and metrics to "support and coordinate federal education and workforce training related to artificial intelligence."[65] NAIIO's interagency committee for education and workforce training will create AI workforce goals and priorities at the federal level.

Recommendations for improvement:

- **Congress should provide funding for low-income and rural school districts to incorporate AI into their high school curricula.**[66] Funding for educational resources for AI remains fragmented. Policymakers should ensure that schools that have the least access to AI resources for education can receive specific funding. Moreover, the Department of Education should work with NAIIO to collect and disseminate best practices in education models and materials through a centralized hub.

- **Congress should create incentives for more tertiary AI by charging and funding NSF to provide grants to public universities (including Minority-Serving Institutions) that have increased or are implementing programs to increase enrollment and retention in AI.** At the university level, policymakers need to address the barriers that limit the number of students able to take AI-related courses. Schools seeking to expand course offerings, hire more faculty, and provide students in AI-related programs such as CS with more resources to improve retention rates should be eligible to apply for these grants. A set of these grants should specifically target Historically Black College and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), and Tribal Colleges and Universities (TCUs) to ensure underrepresented students have equal opportunity to pursue an AI education.

- **Congress should fund a program at NSF to provide competitive awards for up to 1,000 AI researchers to remain in academia for a period of five years.** Even though businesses may benefit from attracting the best AI faculty talent from universities, the overall AI innovation ecosystem suffers as it reduces the number of AI experts that can help new students cultivate these skills. These awards would incentivize more AI researchers to stay in academia and thereby help U.S. universities meet the demand for AI skills.[67]

- **Congress should create a knowledge tax credit to incentivize AI workforce training investment.** Employers are underinvesting in workforce training for AI in the midst of a labor market in which Americans are quitting their jobs in record numbers. Allowing corporations to take a tax credit for at least 50 percent of training expenditures would provide a much stronger incentive for businesses to expand training investments.

- **The Office of Personnel Management (OPM) should change current requirements for many AI positions within the federal government to also allow individuals with acceptable AI certifications to be eligible rather than just those with college degrees.** Doing so would demonstrate to the private sector the feasibility of using alternative credentials for AI.[68] OPM should work with agencies to create the list of acceptable AI certifications for key AI job categories within government and update the list annually.

ATTRACTING FOREIGN AI TALENT

Attracting and securing highly skilled foreign-born talent has played a vital role in U.S. innovation and competitiveness by making up for the deficits in the current U.S. education system in turning out sufficient AI talent. Indeed, 66 percent of students in America's top AI PhD programs are foreign born, more than 50 percent of computer scientists employed in the United States are foreign born, as are about 65 percent of Silicon Valley computer and mathematics workers, and 66 percent of the "most promising" U.S.-based AI start-ups have at least one immigrant founder.[69]

Given the importance of foreign-born AI workers to U.S. innovation success in AI, the United States needs policies to strengthen and expand the immigration pipeline that allows highly trained AI talent to innovate in the United States, including foreign STEM (science, technology, engineering, and mathematics) graduates of U.S. colleges and universities. But while many competitor nations, including the United Kingdom, China, Canada, France, and Australia, have adopted flexible immigration policies to attract foreign talent in AI and other technical fields, the U.S. immigration system has remained largely the same for the last 50 years. These outmoded visa laws, as well as recent anti-immigrant rhetoric and international competition for AI talent from other countries, are causing many international AI scientists and engineers to look outside the United States for education and employment.

Table 1 summarizes the current immigration pathways for four key populations in the AI workforce: students who are pursuing higher education in a field related to AI; workers with higher education degrees who are employed or seeking AI-related positions; "superstar" AI workers who are internationally recognized for their extraordinary ability or achievements in AI or related fields; and entrepreneurs who are planning to start AI-related businesses.

Table 1: Current immigration pathways for foreign-born AI workers to the United States.[70]

	Student	Worker	Distinguished Talent	Entrepreneur
Visa type	The most common visas for international AI students entering higher education in the United States are the F-1 and J-1 visas. Students must be accepted by an approved U.S. institution of higher education.	Most foreign AI workers are eligible for the H-1B temporary work visa. H-1B visas require workers to have an offer of employment from a U.S. company.	Individuals with extraordinary achievement or abilities are eligible for the O-1 temporary visa or EB-1 employment-based green card.	There is currently no visa for AI entrepreneurs. F
Visa duration	Students on F-1 visas are eligible to work for the duration of their program and three years after they graduate with an Optional Practical Training (OPT) status.	The H-1B temporary work visa lasts three years and can usually be renewed once.	Those on the O-1 can stay for three years, with extensions available in some cases. Those on the EB-1 green card can stay permanently.	N/A
Visa caps	There are no set number of F-1 or J-1 visas the United States gives out. About 400,000 F-1 visas were issued in 2017 and 2018.	The H-1B is capped at 85,000 per year, with very few exceptions.	O-1 temporary visas are uncapped. EB-1 employment-based green cards are capped at roughly 40,000 per year. F	N/A
Visa processing times	While processing times can depend on the institution, most F-1 visas are processed within a few weeks.	Applications are selected for adjudication via lottery and must wait to apply during the annual window for registration. Processing of applications can take several months to a year. F	Six to seven months for O-1 and 18 to 20 months for the EB-1 green card. However, Indian and Chinese nationals typically have to wait years. F	N/A
Route to permanent residency	Graduates can either adjust to work visas, though competition is tough, or apply directly for employment-based green cards, which are reserved for those with “extraordinary ability.” F	After six years, H-1B holders can apply for employment-based green cards but these are capped at 140,000 annually (including dependents) and subject to a 7 percent per-country quota. Some workers may have to wait decades to apply. F	Individuals on O status can transition to the EB-1 visa, but the wait times can be very long for some nationals.	N/A
Route to citizenship	Graduates must obtain green cards to become citizens, but this can take decades and Indian and Chinese nationals face the longest wait times. F	Workers must obtain green cards to become citizens. They can apply after five years of residency but caps on green cards mean it can take decades for some, especially Indian and Chinese nationals. F	Those on EB-1 green cards will be eligible for citizenship after five years. Those on O-1 will have to apply for green cards in order to become citizens. F	N/A

For foreign-born students who wish to pursue higher education in a field related to AI, getting a student visa is relatively easy, but staying and working in the United States after graduating is hard. AI graduates can use the STEM Optional Practical Training program to work in the United States for up to three years without getting another visa, but to stay longer, they need to find a job with an employer that is able and willing to sponsor an H-1B temporary work visa, the most important and sought-after channel into the U.S. AI sector for all foreign workers. Most H-1B visas are subject to an annual cap of 85,000, meaning the United States Citizenship and Immigration Services (USCIS) distributes a maximum of 85,000 H-1Bs each year through a lottery-based system that randomly selects grantees from a pool of qualified applicants. Demand for these visas is extremely high, with USCIS receiving approximately 274,000 H-1B registrations in FY 2021 and 308,000 in FY 2022.[71] Even when an AI graduate can find a company willing to complete the expensive H-1B administrative process on their behalf and secure one of the few three-to-six-year H-1B visas, their chances of being able to stay in the United States in the long term are low because the employment-based green cards that confer permanent residency are even harder to come by, as USCIS distributes only 140,000 employment-based green cards each year, at least half of which go to workers' spouses and families.[72] Moreover, under the per-country cap set in the Immigration Act of 1990, workers from any one country cannot be issued more than 7 percent of these green cards, a rule that has not changed in over 30 years even though the sources of migration flows for high-skilled workers have.[73] Today, most international students and workers come from just two countries: China and India.[74] Moreover, Chinese and Indian students have the highest rates of intention to stay when compared with students from OECD member countries.[75] However, the numerical and per-country limits have created employment-based immigration backlogs, which have inordinately long wait times for Chinese and Indian nationals. According to 2020 data from the Congressional Research Center, the average wait time under current law for an EB-2 visa, an employment-based visa for those who hold an advanced degree or equivalent, is 18 years for Chinese nationals and 195 years for Indian nationals.[76] Given the uncertainty and unpredictability that has come to characterize the U.S. immigration process—the Trump administration abruptly began denying Chinese graduate students visas in 2020 based on the Chinese universities they attended amid tensions with the country—it should be no wonder foreign student enrollment declined every year from 2016 to 2020 and international students who graduate with PhDs from U.S. institutions are increasingly taking jobs in other countries. [77] Indeed, 14 percent of all new international AI PhDs that studied at U.S. institutions took jobs outside the United States in 2020, compared with 8.6 percent in 2019.[78]

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For distinguished AI talent that possess extraordinary ability in their field, such as outstanding professors or researchers, there is a temporary, renewable three-year O-1 visa or an employment-based, first-preference EB-1 green card they can apply for. There are no caps on the number of O-1 visas issued each year, but the eligibility requirements have historically been so

demanding and extensive that few organizations rely on these visas to secure talent.[79] In January 2022, the Department of Homeland Security and the Department of State announced that PhD holders in STEM fields would be eligible for the O-1 visa and clarified how STEM talent can meet the requirements for O-1 classification to better attract and retain foreign talent.[80] While a step in the right direction, the guidelines fall short of the policy changes needed to address the severe bottlenecks that exist. There are approximately 40,000 EB-1 visas available to distinguished workers, but current backlogs mean Chinese and Indian workers who have been approved for this visa have to wait an average of 5 and 8 years, respectively, to receive it, which the Congressional Research Center estimates will become an average of 15 and 18 years for these nationals by 2030.[81]

For foreign-born entrepreneurs, there is currently no visa category in the United States, which has long been a beacon of entrepreneurialism, attracting the kinds of people who spark the economy and propel it forward by producing new discoveries, commercializing big ideas, and growing successful companies. But faced with an immigration system that simply ignores them, many foreign-born AI innovators are flocking to cities in countries with more liberal immigration policies.[82] In the United States, foreign-born entrepreneurs are forced to apply for residency through other visa categories that are already oversubscribed, restrictive, complicated, and costly. Take the example of Purva Gupta, cofounder and CEO of the multimillion-dollar retail tech start-up Lily AI, who moved from India to the United States on a student spouse visa. Gupta had to apply and receive six different types of visas before finally obtaining a green card.[83] Over the past few years, however, several countries including Australia, Canada, France, and the United Kingdom have introduced start-up visas they are using to entice foreign entrepreneurs to create Silicon Valley-like tech hubs in their own countries (figure 4).[84]

Figure 4: A billboard over highway 101 in Silicon Valley[85]

Recently, U.S. policymakers have recognized the importance of entrepreneurs to maintaining U.S. competitiveness. The Biden administration revived an immigration program called the International Entrepreneur Parole program, first proposed by President Obama in 2017, which allows foreign entrepreneurs to work for up to five years in the United States granted they hire 10 employees and attract at least $250,000, or meet other benchmarks.[86] The program does not create a new visa category but instead allows the Department of Homeland Security to use its existing authority to permit temporary admission to qualified individuals. The House has already passed the America COMPETES Act, which includes a bill that would create a new temporary visa for eligible international entrepreneurs and essential employees affiliated with the management or operations of a start-up entity.[87] To qualify for the new visa, entrepreneurs must have received at least $250,000 from U.S. investors or $100,000 from government grants, have at least a 10 percent ownership stake and play a central role in the start-up, which itself must be less than five years old. The bill would allow an entrepreneur to receive lawful permanent residence so long as the start-up entity meets certain additional benchmarks, while families of visa holders would be eligible for dependent visas. Ensuring this bill passes through the Senate will be particularly important for AI competitiveness given many of the nation's largest and most successful AI companies were founded by foreign-born entrepreneurs. A 2020 report on AI start-ups finds that two thirds of *Forbes*'s list of the "most promising" U.S.-based AI start-ups have at least one first-generation immigrant founder and 42 percent have founders that are exclusively first-generation immigrants.[88] In crafting the visa, the United States should look to what other nations have established in the past few years. While many of those policies may sound promising, a number of them have failed in practice due to unrealistic and vague metrics for business success or long processing times.[89]

Recommendations for improvement:

- **Congress should better enable immigrants holding AI-relevant graduate degrees to apply for and receive a green card, with preference given to those with degrees from U.S. universities,.** To do this, Congress should eliminate per-country caps on employment-based green cards that have created a bottleneck preventing AI graduates with job offers in hand from contributing to the U.S. AI workforce in the long term.

- **Congress should pilot a visa program for AI entrepreneurs.** Entrepreneurs should be required to show evidence of how their business would support U.S. AI innovation or competitiveness and have received funding in the range of $500,000 from U.S. investors. Policymakers should look at the successes and failures of entrepreneur visas created by several peer countries in the past five years to ensure a U.S. one is successful.

FACILITATING ACCESS TO AI RESOURCES

Overall grade: Approaching expectations

Reason: There is not sufficient access to computing resources for AI researchers in the public sector.

Access to data and computing facilities is a key enabler of AI innovation. AI systems often rely on vast quantities of data for training, as large datasets help AI systems develop highly accurate models to perform tasks ranging from identifying faces to answering search queries. Moreover, machine learning models can recognize subtle patterns in large datasets that are difficult or impossible for humans to perceive. This is one reason many AI systems perform certain tasks better than human experts do, such as identifying the signs of breast cancer in mammograms.[90] In addition, technologies such as high-performance computing, which expands the capabilities of AI systems through massive computational power, and cloud computing, which is a powerful technical architecture for AI that makes access easy and economical, are driving growth, productivity, and innovation. For example, researchers have combined supercomputers and machine learning techniques to model climate change, and companies in the finance and insurance industry are using cloud computing and AI to detect fraud, identify financial risk, and predict cash flow events.

The role of government in increasing access to AI resources for academic and private sector researchers is different. Academic researchers typically conduct crucial early stage AI research that provides foundational, generic knowledge that everyone—including industry—can draw on for ideas and innovation. However, only well-resourced institutions provide access to expensive AI resources, such as powerful AI compute. The government's role is to ensure as many qualified academic researchers as possible have access to AI resources in order to expand the pool of general AI knowledge for the benefit of everyone. Private sector researchers typically conduct later-stage R&D, which is important in bringing innovations to market. The private sector already has incentives to invest in AI resources. The role for government is to ensure the private sector's incentives to invest in R&D for AI are sufficient to maximize overall economic welfare.[91]

Currently, publicly funded academic researchers requiring access to high-performance computing capabilities for AI, which includes access to relevant hardware, software, and expertise, can use resources that are hosted at either their academic institutions or national High Performance Computing (HPC) centers. Allocations for computing time on HPC systems at the national level are made principally through competitive processes managed by the Department of Energy and NSF, respectively. As the Center for Data Innovation found in a 2020 report, however, the demand for access to the systems these agencies provide is more than three times greater than the supply, which is "hampering the ability of AI researchers to develop new products and services that are vital in maintaining U.S. competitiveness, inhibiting AI practitioners from applying AI to defense innovation, and slowing

innovation needed to address important societal challenges, including in health care and the environment."[92]

Moreover, there is a growing divide in the computing resources and opportunities available to both researchers in academia and those in the private sector, which is weighing the nation's research portfolio toward applied, market-driven endeavors. Consider, for example, that in January 2022, Meta (a.k.a. Facebook) announced its state-of-the-art AI research supercluster, a computing system it believes "is among the fastest AI supercomputers running today and will be the fastest in the world once fully built out in mid-2022."[93]

Fortunately, the United States has begun an ambitious initiative to increase access to AI resources for academic researchers. As part of the National AI Initiative Act of 2020, Congress directed a task force to create a roadmap for an NAIRR, envisioned as "a shared computing and data infrastructure that would provide AI researchers and students across scientific fields with access to a holistic advanced computing ecosystem."[94] As of April 2022, the task force had held seven public meetings to investigate the feasibility and advisability of the resource and to develop the roadmap for how it should be established and sustained.[95] The EU is also working to spread access to resources that will support AI development. Consider European High Performance Computing Joint Undertaking (EuroHPC JU), a joint initiative between the EU, other European countries, and the private sector to develop a high-end HPC ecosystem in Europe.[96] The goal of the initiative is to coordinate and pool public and private resources to fund high-end systems in a number of designated sites across the continent. The EU also has a strategy for data and is establishing common European data spaces.[97] Meanwhile, the U.S. effort is unique in its laser focus on AI. The chief driving force behind the initiative is to drive U.S. innovation and competitiveness in AI specifically rather than U.S. innovation and competitiveness generally—and strategic decisions from what systems should be included to what data should be shared and how to which users should have access are being decided with this goal in mind.

Recommendations for improvement:

- **U.S. policymakers should promote secure, energy-efficient AI compute.** Opponents to creating a national computing and data resource claim a new resource would consume too much energy, accelerate climate change, raise serious privacy and security concerns, increase economic inequality, further entrench big tech monopolies, and fuel the proliferation of inherently biased AI systems.[98] While some of the issues raised around data security and energy use are real and deserve smart, considered responses, most claims are at best misleading and lack context, and at worst are just plain wrong and therefore should not shape policy responses. To address legitimate concerns, policymakers should embrace pragmatic responses to minimize any negative impacts from creating the resource, such as minimizing its energy consumption by

prioritizing computationally efficient hardware and algorithms when designing and developing it.[99]

- **OSTP and NSF should prioritize the development of tools and metrics to quantify the AI computing needs and resources of the academic community.** There is little literature on what level and type of compute AI researchers need.[100] Without this information, policymakers cannot effectively make decisions about what resources to invest in or how much.

- **The NAIRR Task Force should prioritize providing local AI computing resources in regions where the gap between AI compute demand and supply is greatest.** As the Center for Data Innovation explained in its comments to OSTP and NSF, some communities, institutions, and regions already have high access to HPC availability, while others are conducting high levels of AI research but have little access to powerful systems.[101] There should be demonstrable evidence that providing access to AI compute in a community, institution, or region would result in an increase in AI research, because democratizing access to AI compute is a means to an end, not an end in and of itself.

PROMOTING GOVERNMENT ADOPTION OF AI

Overall grade: Approaching expectations

Reason: Policy actions are not sufficiently focused on addressing structural issues that are stalling government adoption of AI including approach and culture; financing; metrics and incentives; procurement; and oversight and review.

One of the most important things government can do to spur AI is to be a robust adopter of AI technologies. Beyond improving agency mission delivery, removing barriers to public-sector adoption of AI would help reduce the perceived risk of the technology and boost domestic demand for AI innovation in the private sector.

Congress and the White House have taken important steps recently to facilitate greater government adoption of AI, but many agencies still face unique challenges to becoming more AI-mature organizations. Indeed, deployment of AI in the federal government is relatively low despite 70 percent of public sector IT leaders agreeing that AI is "mission critical."[102] The challenges facing agencies include outdated IT infrastructures, limited funding for capital expenditures, lack of awareness about the technology, and risk aversion, among others.

One key and oft-cited challenge is a shortage of government workers equipped to work with AI. While this obstacle is not unique to government, federal agencies struggle to compete with the private sector in attracting and retaining AI talent. And as the demand for workers with AI skills increases, the government has an even harder time recruiting this talent, as the private

sector has greater flexibility to offer more attractive salaries and benefits. According to a 2019 *New York Times* article, AI specialists with little industry experience can make between $300,000 and $500,000 a year in salary and stock in the private sector, with top names in the field receiving compensation packages that extend into the millions.[103] The government cannot match these salaries. Without AI expertise, procurement managers in government are less able to effectively facilitate AI adoption and government agencies will be less aware of the ways in which AI could benefit their missions.

The bipartisan AI Training Act, which passed in December 2020, was an effort to address this challenge by directing the Office of Management and Budget (OMB) to establish an AI training program for a variety of federal employees, with a focus on courses that teach the basics of AI, the ways the technology can benefit the federal government, and the risks it poses, particularly to privacy and discrimination risks.[104] Similarly, the AI in Government Act of 2020 directs OPM to study how to foster the necessary workforce skills for effective AI adoption within government. This legislation also established an AI Center of Excellence (AI COE) within the General Services Administration (GSA) to deploy and scale AI solutions across government agencies.

To be sure, having federal managers and employees better understand and care about the process of AI innovation and how to apply it to their work will help facilitate government adoption of AI, but structural factors play a much more important role in limiting and enabling innovation across the federal enterprise.[105] It is usually not the case that federal managers don't innovate with AI because they don't know innovation is useful; they don't innovate because there are few rewards and many barriers. Policy actions focused predominantly on the importance of federal managers embracing innovation is unlikely to do much to move the needle on large-scale government adoption of AI. Policymakers should be focused on addressing structural factors related to approach and culture; financing; metrics and incentives; procurement; and oversight and review. The U.S. government has great potential to use AI to improve its public services and gain strategic economic advantages— in 2021, it ranked highest out of 160 countries in a government AI readiness index by consultancy firm Oxford Insights.[106] Policymaker inaction to overcome structural challenges is wasteful.

Recommendations for improvement:

- **The AI COE situated within GSA should identify 20 to 50 core processes to be transformed with AI.** The challenge of innovation in the federal government is to innovate on large-scale, core processes, but senior managers are typically attracted to novel, pilot-scale AI services that are often useful but do little to change the status quo. According to a 2017 report by Deloitte, more than 10 percent of the 4.3 billion work hours federal government employees spend is used for documenting and recording information, and another 10 percent is spent on monitoring resources or processes and surroundings.[107] AI COE should identify the most important core processes in which AI

can make a difference. Ideally, these would be ones where AI would either lead to significant improvements in customer service and quality or reductions in cost (to both the government and users of government services).

- **Congress should allow agencies to divert a small share of their operating budgets to AI innovation projects.** Congress should create a federal analogue to the Small Business Innovation Research program, which allocates a small share of federal extramural R&D to small business innovation contracts. The analogue here would be that Congress could allow agencies to allocate a small share of their operating budgets (perhaps half a percent) to serve as an internal innovation seed fund to let agencies start pilot projects more easily. IT leaders within the federal enterprise such as chief information officers or chief AI officers should have discretion over these funds to strengthen their agency roles. The authority could expire after five years, after which the U.S. Government Accountability Office (GAO)would assess the results.

- **Each federal agency should develop its own AI strategy and appoint a chief AI officer.** One reason certain agencies devote so little attention to AI is that it is generally not formally recognized as part of agency agendas or strategic plans. Each agency should explicitly identify specific steps for how it will connect its data, users, and mission priorities to support AI transformation, much like the Department of Defense, Department of Veteran Affairs, and Food and Drug Administration already have. To really coordinate and drive implementation of AI, each federal agency should consider appointing a chief AI officer, like the Department of Health and Human Services has done.

- **AI COE should develop an all-encompassing procurement website for federal AI contracts.** One-stop e-procurement websites and e-quoting allows private sector firms to easily locate and apply for government contracts. Currently, most federal contracts for AI services are awarded to companies concentrated on the East Coast, close to where federal agencies are located. Indeed, approximately 87 percent of the federal contracts awarded for robotic process automation went to companies in Virginia and New York.[108] An online portal for all contracts could help make public procurements available to firms all across the country, ensuring the government gets the best services and spreads economic opportunity across the United States.

- **GAO and Council of the Inspectors General Should Call Out Agencies for Not Innovating with AI.** Rather than looking at waste, fraud, and abuse alone, these organizations should look at waste and inertia from lack of AI innovation. The federal government has been aware of the need to digitize paper form processing and automate manual processes since the early 2000s, and slow adoption of AI has cost taxpayers a lot of money. It should therefore hold federal agencies accountable for not innovating.[109]

DEVELOPING TECHNICAL STANDARDS

Overall grade: Meeting expectations

Reason: Greater government engagement in international standards setting is needed to promote the voluntary, industry-led approach to standards that has been successful at bolstering AI innovation in the United States.

When one considers policies designed to drive innovation and competitiveness, those related to standards development and implementation are often underappreciated, or even ignored. But a robust ecosystem of standards is foundational to a nation's ability to effectively develop and implement AI systems for two key reasons. First, technical standards for AI, which can encompass a wide variety of issues, including safety, accuracy, usability, interoperability, security, reliability, data, and even ethics, can provide developers with clear guidelines for the design of AI systems. This helps maximize the utility from AI systems by ensuring they can be easily integrated with other technologies, utilize best practices for cybersecurity and safety, and adhere to a variety of different technical specifications. Second, common standards can serve as a mechanism to evaluate and compare AI systems. For example, in some contexts, there may be a legal requirement for transparency for a decision-making process, such as judicial decision-making.[110] However, without clear standards defining what algorithmic transparency actually is and how to measure it, it can be prohibitively difficult to objectively evaluate whether a particular AI system meets these requirements or expectations, or does so better than another similar system, which discourages the adoption of these technologies. [111]

The U.S. approach to standards development for AI follows the general U.S. standards system, which has been exceptionally successful in generating technological innovation in the United States. The U.S. standards system focuses on voluntary consensus standards that are created by private sector standards development organizations in response to particular needs or issues identified by industry stakeholders, government, or consumers. For instance, the Society of Automotive Engineers has developed definitions and specifications of autonomy that autonomous vehicle manufactures rely on to adhere to rules from the Department of Transportation. And the U.S. tech association brought together 50 technology and health organizations in 2020 to establish the first ever standard for AI in health care accredited by the American National Standards Institute (ANSI), building consensus on such terminology as "telehealth" and "remote patient monitoring."[112]

There are two categories that broadly describe how standards achieve adoption in America. De facto standards achieve adoption through competition among rival standards consortia. Consider the Open Neural Network Exchange (ONNX) and the Neural Network Exchange Format (NNEF), two examples of open data exchange protocols developed by private-sector consortia to enable interoperability between different frameworks for training, executing, and deploying machine learning models.[113] In the de facto method, the market informally decides which protocol achieves the dominant

position, ensuring that the one with the best technical merit wins out. De jure standards are also adopted through consensus, but they are usually approved and endorsed by formal standards authorities. For instance, NIST, a nonregulatory federal agency within DOC, has developed and approved a succession of data format standards for the interchange of fingerprint, facial, and other biometric information in response to government and market needs by collaborating with other federal agencies, academia, and industry.[114]

The role the federal government has played in standards has historically been limited, primarily focusing on orchestrating and supporting industry-led efforts through technical assistance with reference materials, data, and instrumentation. In February 2019, the Trump administration called on NIST to take a more engaged role in developing AI standards, issuing an executive order that, among other things, directed the agency to create "a plan for Federal engagement in the development of technical standards and related tools in support of reliable, robust, and trustworthy systems that use AI technologies."[115] The plan, which was released in August 2019, helped to establish a federal AI standards coordinator within NIST charged with gathering and sharing AI standards-related needs and best practices, and to promote research that underlies technically sound standards for trustworthy AI. Regarding the latter, NIST drafted "A Taxonomy and Terminology of Adversarial Machine Learning" in 2019, "Four Principles of Explainable Artificial Intelligence" in 2020, and "A Proposal for Identifying and Managing Bias in Artificial Intelligence" in 2021.[116] In response to a directive from Congress in the 2021 omnibus spending bill, NIST is also developing a voluntary framework to manage the risks to individuals, organizations, and society from AI systems.[117]

While the generally pluralistic, demand-driven, market-led approach to standardization remains successful in generating innovation, times have changed since the first standards organizations were established in the late 19th century. The U.S. economy is no longer localized and agricultural as it was then and has instead transformed into a globalized, data-driven, and algorithmic economy in which the ability to use AI is proving critical to firms' success. The role the government plays in international standards setting is therefore increasingly critical, as divergent AI standards make it more difficult and costly for global firms to sell their AI products because it means they have to reconfigure preexisting design and production processes to suit the specific standards in different markets and pay royalty fees for providing products using the local standard.[118] Even worse, divergent standards can impede the development and deployment of AI systems if stakeholders don't coalesce around one widely agreed upon approach. For example, AI firms (and investors) may choose to reduce or hedge their investments as they wait and see which standard prevails.[119]

DOC, NIST, ANSI, and other agencies are rightly involved in developing international standards for AI—the United States plays a leading role in the international standards committee responsible for developing AI standards (ISO/IEC JTC 1/SC 42)—but U.S. policymakers should more actively counter

state-directed, restrictive, and discriminatory approaches to standards setting from other countries. The European Union's AI Act, for example, would mandate firms developing or implementing high-risk AI systems use standards developed and published by two regional organizations: CEN and the European Committee for Electrotechnical Standardization (CENELEC). While mirror agreements between CEN and the International Organization for Standardization (ISO) and CENELEC and the International Electrotechnical Commission (IEC), respectively, give priority to the adoption of international standards as harmonized European standards, Article 41 of the EU's AI Act creates legal channels for the EU to develop and apply region-specific technical specifications where it is determined that relevant standards are insufficient or do not exist.[120] This presents a clear risk of the EU developing specifications outside transparent, consensus-based, and industry-driven international standards development organizations that hurt U.S. firms.

Finally, U.S. policymakers are both justifiably concerned about a loss of AI competitiveness to China—which has established a comprehensive and state-driven strategy for standards to bolster its own competitiveness—and wary of the potential for unfair strategic gamesmanship in AI standards-setting organizations by Chinese actors. In the past, China has intentionally created domestic standards that differ from prevailing international standards as a way of favoring Chinese products and keeping out foreign ones, such as in 2003 when it mandated that all wireless devices support the WAPI encryption standard, which is incompatible with encryption standards used by other nations.[121] Recently, China has indicated it is seeking more international alignment. In its national strategy for technical standards released in 2021, China outlines that it wants to align 85 percent of its domestic standards with international ones.[122] While many policymakers may look at the target itself with skepticism, it more broadly signals a move toward harmonization. The concern among U.S. policymakers, including the Department of Justice, is that China may intend to use its increased engagement with international standards organizations to bias global standard development processes in favor of their own interests, including for AI competitiveness.[123]

Recommendations for improvement:

- **NIST and DOC should work with the United States Trade Representative (USTR) to launch an Indo-Pacific Standards Strategy for AI.**[124] The White House has already launched an Indo-Pacific Economic Framework (IPEF) to strengthen the U.S. relationship with the region. It should use this opportunity to better connect standards-making bodies and related government agencies (and relevant industry experts) on the development and use of standards for AI, especially given that China's national strategy for technical standards calls for more alignment within countries that are participating in the Belt and Road Initiative and standards-related dialogues with members of BRIC and the Asia-Pacific Economic Cooperation forum.[125]

- **The National AI Office should work with NIST to create an AI Standards Hub.** The United Kingdom is piloting such a hub, intended

to "create practical tools for business, bring the UK's AI community together… and develop education materials to help organizations develop and benefit from global standards."[126] Not only should the United States pilot its own hub to better enable organizations to engage in creating technical standards for AI, but it should also collaborate with the United Kingdom and bolster information sharing.

- **The United States should use the U.S.-EU Trade and Technology Council (TTC) discussions to counter EU proposals to pursue regional AI standards.** Because the EU's AI Act creates legal loopholes for the bloc to create and apply region-specific technical specifications for AI where it is deemed that relevant standards are insufficient, the United States should use the TTC working group on tech standards to establish commitments on AI standards that ensure those that are developed are based on industry-driven, consensus-built standards.

LEGAL AND REGULATORY POLICIES

ENSURING AI REGULATION IS INNOVATION FRIENDLY

Overall grade: Meeting expectations

Reason: **Recent policies and rhetoric signal a shift away from what has been a successful light-touch regulatory approach to AI.**

Designed properly, regulations can spur AI innovation and productivity by reducing regulatory uncertainty and rewarding beneficial actions. A good regulatory climate certainly does not simply mean the absence of regulations. Instead, it is one that supports rather than blocks AI innovators and creates the conditions to spur ever more innovation and market entry, while at the same time providing more regulatory flexibility and efficiency for industries in traded sectors.[127]

The U.S. approach to AI regulation is generally sector specific with executive branch agencies promulgating regulations in their domain. For instance, the Department of Transportation regulates the use of autonomous vehicles while the Food and Drug Administration regulates AI-based medical devices. All agencies go through an extensive public notice and comment period in which individuals and organizations can submit written comments the agencies are required to review. This has generally been a strength of the U.S. system, which enjoys a legislative framework that works to hold government executive agencies accountable for obtaining public input and basing rules on evidence.

Congress can sometimes require executive branch agencies to promulgate regulations or can pass legislation itself. For instance, Senator Cory Booker (D-NJ), Senator Ron Wyden (D-OR), and Representative Yvette Clark (D-NY) introduced the Algorithmic Accountability Act in the House in February 2022, which would direct the Federal Trade Commission (FTC) to develop regulations requiring large firms to conduct impact assessments for existing and new high-risk automated decision systems.[128] The number of proposed bills that relate to AI in the federal legislative record has increased sharply

over the past few years. In 2015, only one federal bill was proposed, while in 2021, there were 130.[129] Still, very few federal-level AI bills are being passed into law. For instance, only 3 of the 130 bills proposed in 2021 were passed.[130]

In general, the U.S. federal government, more so than any other government, has adhered to the innovation principle in its early regulation of AI, which holds that because the overwhelming majority of AI innovations benefit society and pose modest and not irreversible risks, government's role should be to pave the way for widespread innovation while building guardrails, where necessary, to limit harms.[131] This approach recognizes that market forces, tort law, existing laws and regulations, or light-touch targeted interventions can usually manage the risks new AI technologies pose.[132]

Under the Trump administration in early 2020, the White House unveiled a set of principles for AI regulation as a follow-up to a 2019 executive order titled "Maintaining American Leadership in Artificial Intelligence," which outlined a series of steps for the federal government to ensure the United States remains at the forefront of technological innovation. The 10 principles outlined what federal agencies should take into consideration when crafting their approaches to AI:

- Promote "reliable, robust, and trustworthy" AI
- Provide opportunities for the public to weigh in during the rulemaking process on quality
- Hold information to high standards of "quality, transparency, and compliance"
- Assess and manage risks recognizing that all activities involve trade-offs
- Seek to maximize the "net benefits" of AI
- Prioritize adaptability in order to keep up with rapid technological advancement
- Be mindful of the potential for discrimination and bias
- Weigh existing and potential new measures for transparency and disclosure
- Consider safety and security throughout the development and deployment process
- Take a "whole-of-government approach" to ensure consistency and predictability of AI-related policies.[133]

OMB issued guidance in November 2020 reaffirming these 10 principles the White House drafted, while also reflecting a shift from principles to practice by establishing a framework for federal agencies to assess potential regulatory and nonregulatory approaches to emerging AI issues. For example, the new guidance instructs agencies to precede any regulatory action with an impact analysis that clearly articulates the problem an agency is seeking to address, whether it be a market failure (e.g., asymmetric information), protecting privacy or civil liberties, preventing unlawful discrimination, or advancing the United States' economic and national security.[134] While

indicating the potential for limited, focused regulations in certain areas, the guidance promotes a governance framework that requires agencies to impose regulation only when the benefits of doing so outweigh the costs to AI-driven innovation and growth. The guidelines instruct agencies when deciding whether and how to regulate in an area that may affect AI applications to "adopt a tiered approach in which the degree of risk and consequences of both success and failure of the technology determines the regulatory approach, including the option of not regulating."[135]

President Biden has indicated a shift from this approach, supporting stronger regulations. In April 2021, the FTC published a widely noted blog post on how companies can use AI "truthfully, fairly, and equitably" and shortly after began a rule-making process "to curb lax security practices, limit privacy abuses, and ensure that algorithmic decision-making does not result in unlawful discrimination."[136] Further signaling its shift toward a greater focus on issues of AI harm, the FTC appointed Meredith Whittaker, cofounder of the AI Now Institute, who has written that "the vast majority of AI systems and related technologies are being put in place with minimal oversight, few accountability mechanisms, and little information about their broader implications," to serve as a senior advisor on AI to FTC Chair Lina Khan.[137] Moreover, the president's science advisor and director of OSTP began developing an AI Bill of Rights in October 2021 based on the premise that current AI and biometric technologies have led to serious problems regarding discrimination and bias.[138]

Recommendations for improvement:

- **Policymakers should pursue an innovation-friendly framework built around the principle of "algorithmic accountability" in which the operators of algorithms are held accountable for explicit and severe harms.** The framework advocates that governments hold companies accountable for the outcomes of the AI they use by discerning whether there was injury, the operator had sufficient controls to verify its AI worked as intended, and the operator rectified harmful outcomes.[139]

- **Congress and the administration should support increasing the technical expertise of regulators and policymakers.** Regulators should foster relationships with communities of developers, academics, civil society groups, and private-sector organizations invested in algorithmic decision-making to stay abreast of technical developments and concerns about algorithmic harms that could influence how algorithmic accountability is achieved or enforced. This requires ensuring regulators have the resources to hire staff with the necessary technical expertise to scrutinize algorithms.[140]

- **Policymakers should continue the tried-and-true approach of addressing AI concerns by sector.** U.S. policymakers should recognize that AI is a tool, and the locus of regulation should not be the tool but rather the application of the tool. The focus should be on a discrete number of sector-specific applications and tailoring regulations that prevent specific harms.

- Congress and the administration should caution regulators against viewing the mere act of collecting or possessing large amounts of data (which is necessary for specific uses of AI) as anticompetitive behavior.[141]

CULTIVATING STRONG INTELLECTUAL PROPERTY (IP) RIGHTS

Overall grade: Approaching expectations

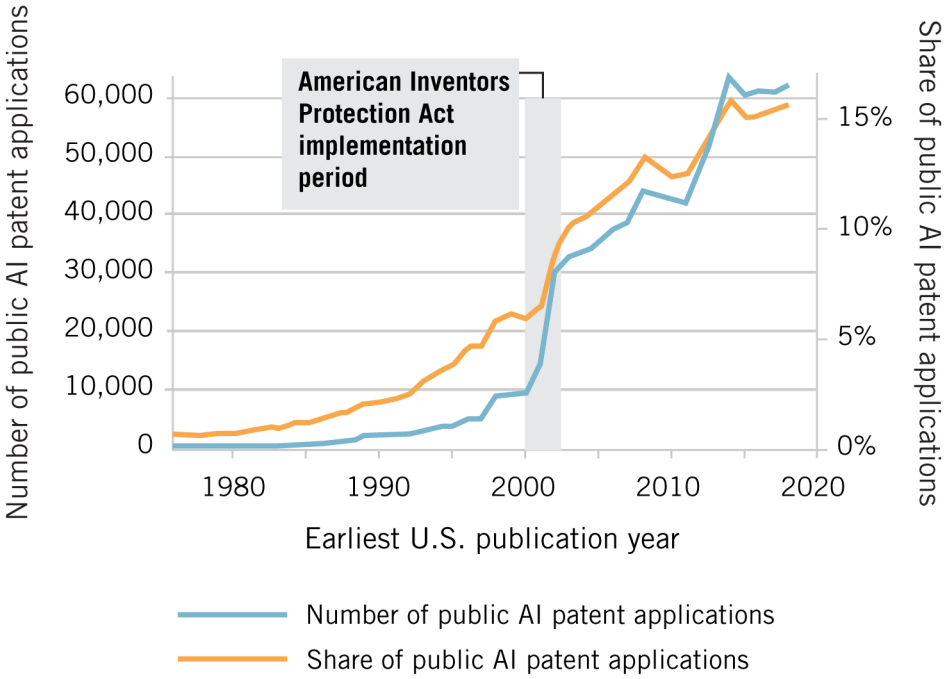
Reason: There are uncertainties in the IP system for AI that are hindering innovation.

IP rights have long been recognized as fostering innovation. The idea is that those who combine the spark of imagination with the grit and determination to see their vision become reality in books, technology, medicines, designs, sculpture, services, and more deserve the opportunity to reap the benefits of their innovation—and that these rewards incentivize more creative output.[142] While the United States is a global leader in IP rights protection, certain developments—both domestically and internationally—are creating some uncertainty for global entities.[143] In particular, the advent of AI raises the prospect that some works are now the direct output of computer systems, including some operating autonomously. Jurisdictions around the world are divided on how to handle the "AI inventor" while continuing to enable innovation.[144]

U.S. policy on IP rights as they relate to AI has focused predominantly on two questions: whether AI-created works are eligible for protections, and if they are, who should be recognized as the author or inventor with controlling rights. In general, the U.S. Patent and Trademark Office (USPTO), which is responsible for granting patents and trademarks, has rightly recognized that AI is a tool and that the owner and operator of the AI system should be the default owner of any IP it produces. It stated, in a recent report, "AI inventions should not be treated any differently than other computer-implemented inventions. This is consistent with how the USPTO examines AI inventions today. AI inventions are treated like all other inventions that come before the Office."[145] The U.S. Copyright Office, which registers copyrights, requires a minimum threshold of human creativity for a work to qualify for copyright protection and will not grant a registration to a wholly AI-generated work to a system.[146]

That does not mean the overall IP system does not need reform in light of AI. For one, offices and courts are facing challenges deciding which AI-based inventions are patent eligible under the law, which becomes more problematic as the volume and share of AI patents in the United States increases rapidly (figure 5).

Figure 5: The volume and share of public AI patent applications[147]



Patent eligibility in the United States is based on section 101 of the Patent Act, which says that an invention is new, has some practical use, and is non-obvious. However, the Supreme Court through some landmark cases has identified three categories of work that are judicial exceptions, meaning they are ineligible from this broad conception of eligible subject matter. These are laws of nature, natural phenomena, and abstract ideas. Because AI patents generally rely strongly on mathematical relationships and algorithms, they may be considered abstract ideas under patent law. Patent examiners, who must determine whether an AI invention is patentable, are hindered by such uncertainties and in turn have rejected a significant portion of AI patents that should have received protections. To address this issue, the USPTO issued guidance in 2019 that clarifies what would be considered ineligible concepts and provides examples to guide the examination process. According to former USPTO director Andrei Iancu, the guidance has cut rejection rates for AI from 60 percent to 32 percent.

Still, because of the unpredictable and uncertain nature of the U.S. patent system, many AI innovators turn to trade secrets to protect their work.[148] Trade secrets have a number of advantages over other IP. The information protected by trade secrets does not need to be novel, is protectable immediately without the cost or lengthy registration timelines other IPRs require, and is protected for as long as the information is commercially valuable and can be maintained as secret.[149] However, the key distinction between trade secrets and other forms of IP that is relevant to AI innovation is the trade secrets work by protecting information that is undisclosed as opposed to patents, for example, where the IP is publicly disclosed. According to NSCAI, because trade secrets do not contribute to accessible technical knowledge in the public domain, they may hinder AI innovation in the long

term more than they bolster it.[150] Another disadvantage is trade secrets do not offer protection from reverse engineering.

Recommendations for improvement:

- **The USPTO should reassess any obstacles that may be hindering patent examiners in their prosecution of AI patents.** As it did in 2019, the USPTO should continue to revise guidelines to streamline the process as much as possible.

- **Congress should direct both the secretary of Commerce and the secretary of Commerce for Intellectual Property to review the impact of trade secrets on AI innovation.** They should evaluate any reforms to IP policies and regimes that may be needed to incentivize, expand, and protect AI and work with the director of the USPTO to obtain AI patent-related data.

- **Congress and the White House should work with the USPTO, Copyright Office, State Department, and any other relevant agencies to craft a national strategy for AI that cultivates strong IP rights.**

FOSTERING AI DEVELOPMENT THROUGH TRADE POLICIES

Overall grade: **Approaching expectations**

Reason: **More agreements for cross-border data flows and export controls that focus on AI manufacturing equipment are needed.**

CROSS-BORDER DATA FLOWS

The practices of other countries can have a significant impact on how effectively U.S. firms can develop and deploy AI. In particular, efforts to restrict how data can move across borders limits the amount of data at the disposal of U.S. businesses innovating with AI. The number of these types of measures in force around the world has more than doubled in four years. In 2017, 35 countries had implemented 67 barriers to restrict the free flow of certain kinds of valuable data, including certain kinds of financial data, personal data, and data from emerging digital services such as online publishing. In 2021, 62 countries had imposed 144 restrictions—and dozens more were under consideration.[151] The justifications for these measures are often seemingly legitimate, such as those to preserve privacy and security, but rules that require data to be stored domestically do not guarantee either.[152] In reality, the primary motivation behind these approaches is mercantilist in nature, designed to prop up domestic industries at the expense of productivity.[153]

The United States has had mixed success in protecting cross-border data flows in past trade agreements. The Trans-Pacific Partnership (TPP), now the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), was the first international trade agreement with explicit language governing the flow of data across borders. The CPTPP includes prohibitions against localization requirements that would force businesses to build data

storage centers or use local computing facilities when providing digital services; protections for proprietary software source code; and a commitment to cooperate on cybersecurity through coordinated national computer emergency response teams.[154] Unfortunately, the United States withdrew from the agreement in 2017, and the remaining 11 nations—Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, and Vietnam—forged ahead with a deal that concluded in 2018. It appears unlikely the Biden administration will rejoin given residual political opposition to it.[155] However, the United States secured protections for cross-border data flows in the United States-Mexico-Canada Agreement (USMCA), which came into force in July 2020.[156] In addition to preventing parties from enacting protectionist data localization requirements, the USMCA includes protections for algorithmic source code and promotes the publication of open government data. Regarding the latter, the deal does not require parties to publish open government data but instead supports the availability of valuable open data as a public resource that can spur AI development.[157] These sorts of data-related provisions are important for AI development and should serve as a model for future trade negotiations.

In the same month USMCA came into force, the European Court of Justice made a decision to invalidate the EU-U.S. Privacy Shield, which thousands of organizations relied on to legally transfer data abroad for operations, customer service, communications, R&D, and human resources.[158] While both the EU and the United States have agreed on legal tools to establish transatlantic data flows in the past—initially the U.S.-EU Safe Harbor in 2000, and more recently the EU-U.S. Privacy Shield—EU courts have undermined these efforts twice with the *Schrems I* and *Schrems II* rulings. If policymakers do not create an alternative to the EU-U.S. Privacy Shield, firms from a broad range of sectors on both sides of the Atlantic will suffer.[159]

In October 2021, President Biden announced the United States' intention to explore the development of an IPEF to strengthen U.S. ties in the Asian region. While the IPEF will not be a trade agreement, it will include trade commitments and is therefore an opportunity for the United States to create frameworks for data sharing and data trust that support AI.

Recommendations for improvement:

- **The United States should use the IPEF to support the development of joint data trusts and other data-sharing models to improve the quality (and quantity) of the data that is a key input to AI.** The IPEF presents an opportunity for the United States and its trading partners to identify, develop, and support data-sharing models organizations in many sectors will not develop on their own.[160]

- **The United States and EU should conclude a new Privacy Shield framework to guarantee the free flow of data across the two jurisdictions.** Without such an agreement, the entire transatlantic digital economy risks fracturing in the coming years as courts strike down ever-greater numbers of data flow arrangements. Any such agreement should also clarify the legal definition of "personal data"

under Article 4(1) of the General Data Protection Regulation (GDPR).[161]

- **The United States Trade Representative (USTR) should continue to fight source code disclosure requirements other nations may enact to unfairly disadvantage U.S. firms or exploit their IP.**

AI CHIPS

Trade disputes can put a nation's ability to secure semiconductors, including AI chips, at risk. Having access to state-of-the-art AI chips is important to ensure AI developers and users can remain competitive in AI R&D and deployment. There is already an emerging set of AI chips that are specialized for different tasks, which fall broadly into three categories. The first is graphics processing units (GPUs), which are mostly used to train and develop AI algorithms. The second is field programmable gate arrays (FPGAs), which are mostly used to apply trained AI algorithms to new data inputs. FPGAs are different from other AI chips because their architecture can be modified by programmers after fabrication.[162] The third group of AI chips is application-specific integrated circuits (ASICs), which can be used for either training or inference tasks. ASICs have hardware that is customized for a specific algorithm and typically provides more efficiency than FPGAs do, but because they are so narrow in their application, they grow obsolete more quickly as new AI algorithms are created.

There is increasing demand from AI developers for specialized chips that are more efficient for AI because the rate of improvements in traditional processing chips is getting slower as the ability to pack more transistors onto a single processor is beginning to reach its physical limits. Fortunately, the United States is still the world leader in designing chips for AI systems. The Center for Data Innovation's 2021 report *Who Is Winning the AI Race: China, the EU, or the United States? — 2021 Update* finds that at least 62 firms in the United States are developing AI chips, compared with 29 firms in China and 14 in the European Union.[163] The United States has many advantages for AI chip production, including high-quality infrastructure and logistics, innovation clusters, leading universities, and a history of leadership in the field. Moreover, Chinese AI chip firms are reliant on U.S. electronic design automation software, which is the category of software tools for designing electronic systems such as integrated circuits.[164]

However, continued leadership is not promised. China has targeted the industry for a global competitive advantage, as detailed in a number of government plans, including "Made in China 2025," and while some of its policy actions are fair and legitimate, many seek to unfairly benefit Chinese firms at the expense of more-innovative foreign firms. [165] Even though some argue it should not matter where AI chips are fabricated so long as U.S. companies have access to the ones they need, it matters for a multitude of economic and national security reasons, including that the industry supports hundreds of thousands of U.S. jobs, both directly and indirectly, and that AI is critical to the Department of Defense's mission.[166] To keep America's AI chip industry competitive, Congress needs to pass two critical pieces of legislation

that would support the United States manufacturing more semiconductors domestically: the Creating Helpful Incentives to Produce Semiconductors (CHIPS) Act, which is part of USICA, and the Facilitating American-Built Semiconductors (FABS) Act.

Recommendations for improvement:

- **The United States should coordinate the development of AI chips with like-minded countries.** Successfully innovating in the semiconductor sector requires an expense and scale that make it tough for any one country to do alone. As ITIF explained in *An Allied Approach to Semiconductor Leadership*, the United States should coordinate technology development with its allies. This could include establishing Manufacturing USA Institute(s) to support AI chip industry innovation—in activities including R&D, manufacturing, and packaging—and invite participation by semiconductor enterprises headquartered in like-minded nations.[167]

- **The United States should coordinate export controls of AI chip manufacturing equipment with its allies.** Overly broad export controls on AI technologies, such as general-purpose AI software, can delay U.S. firms in getting innovative products to market, thus harming their competitiveness.[168] Policymakers should be pursuing tailored export controls on application-specific AI software and dual-use datasets. However, they should note existing export control regimes already adequately protect many of these. The area where new export control regulations are likely to be most effective is on AI chip manufacturing equipment, where the United States and its allies dominate the market.[169] By controlling the export of semiconductor equipment, the United States can better protect against unfair replication, illicit transfer, and theft of its semiconductor technology. The United States should coordinate the development of controls with its allies because export control regimes are most successful when they are coordinated internationally.[170]

Endnotes

[1] Daniel Zhang et al., "The AI Index 2022 Annual Report" (AI Index Steering Committee, Stanford Institute for Human-Centered AI, Stanford University, March 2022), https://aiindex.stanford.edu/wp-content/uploads/2022/03/2022-AI-Index-Report_Master.pdf.

[2] Mark Zachary Taylor, *The Politics of Innovation: Why Some Countries Are Better Than Others at Science and Technology* (New York: Oxford University Press, 2011), 83.

[3] Ibid.

[4] Neil C. Thompson, "Building the algorithm commons: Who discovered the algorithms that underpin computing in the modern enterprise?" *Wiley* (September 2020), https://onlinelibrary.wiley.com/doi/epdf/10.1002/gsj.1393.

[5] The National Artificial Intelligence Research and Development Strategic Plan (Washington, D.C.: Networking and Information Technology Research and Development Subcommittee, October 2016), https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf.

[6] The National Artificial Intelligence Research and Development Strategic Plan: 2019 Update (Washington, D.C.: Networking and Information Technology Research and Development Subcommittee, June 2019), https://www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf.

[7] The Networking & Information Technology Research & Development Program, Supplement to The President's FY2021 Budget, National Science & Technology Council (Aug. 14, 2020), https://www.nitrd.gov/pubs/FY2021-NITRD-Supplement.pdf.

[8] Ibid.

[9] U.S. Department of Commerce, "President Biden's Fiscal Year 2023 Budget Calls for Critical Investments in Key Commerce Priorities," press release, March 2022, https://www.commerce.gov/news/press-releases/2022/03/president-bidens-fiscal-year-2023-budget-calls-critical-investments-key?.

[10] Robert D. Atkinson, "The Senate Proposal for a New NSF Directorate Is Superior to the House Alternative" (ITIF, January 2022), https://itif.org/publications/2022/01/28/senate-proposal-new-nsf-directorate-superior-house-alternative.

[11] National Security Commission on Artificial Intelligence (NSCAI) Final Report (Washington D.C.: NSCAI Commission Members, March 2021), https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf.

[12] Jess Whittlestone and Jack Clark, "Why Governments Should Monitor AI Development" (Centre for the Study of Existential Risk, August 2021), https://www.cser.ac.uk/news/paper-why-and-how-governments-should-monitor-ai-de/.

[13] Robert D. Atkinson, "The Case for Repealing the R&D Amortization Provision in the 2017 Tax Cuts and Jobs Act" (ITIF, September 2021), https://itif.org/publications/2021/09/07/case-repealing-rd-amortization-provision-2017-tax-cuts-and-jobs-act.

[14] John Lester and Jacek Warda, "Enhanced Tax Incentives for R&D Would Make Americans Richer" (ITIF, September 2020), https://itif.org/publications/2020/09/08/enhanced-tax-incentives-rd-would-make-americans-richer.

[15] Daniel Zhang et al., "The AI Index 2021 Annual Report" (AI Index Steering Committee, Stanford Institute for Human-Centered AI, Stanford University,

March 2021), https://aiindex.stanford.edu/wp-content/uploads/2022/03/2022-AI-Index-Report_Master.pdf.

[16] John Lester and Jacek Warda, "Enhanced Tax Incentives for R&D Would Make Americans Richer" (ITIF, September 2020), https://itif.org/publications/2020/09/08/enhanced-tax-incentives-rd-would-make-americans-richer.

[17] Robert D. Atkinson, "The Case for Repealing the R&D Amortization Provision in the 2017 Tax Cuts and Jobs Act."

[18] "Janet Yellen Testimony on Economic Recovery, 2022 Budget Transcript," last modified June 16, 2021, https://www.rev.com/blog/transcripts/janet-yellen-testimony-on-economic-recovery-2022-budget-transcript.

[19] John Lester and Jacek Warda, "Enhanced Tax Incentives for R&D Would Make Americans Richer."

[20] Robert D. Atkinson, "Effective Corporate Tax Reform in the Global Innovation Economy" (ITIF, July 2009), https://itif.org/publications/2009/07/19/effective-corporate-tax-reform-global-innovation-economy.

[21] Mark Zachary Taylor, *The Politics of Innovation.*

[22] Michael Storper and Anthony J. Venables, "Buzz: face-to-face contact and the urban economy," *Journal of Economic Geography*, Volume 4, Issue 4 (August 2004), 351–370, https://doi.org/10.1093/jnlecg/lbh027.

[23] Robert D. Atkinson, Mark Muro, and Jacob Whiton, "The Case for Growth Centers: How to spread tech innovation across America" (ITIF and Brookings, December 2019), https://www2.itif.org/2019-growth-centers.pdf.

[24] Diana Gehlhaus and Ilya Rahkovsky, "U.S. AI Workforce Labor Market Dynamics" (CSET, April 2021), https://cset.georgetown.edu/wp-content/uploads/CSET-U.S.-AI-Workforce-Labor-Market-Dynamics.pdf.

[25] Author's calculations using county-level occupations from American Communities Survey, "EEO 1W. Detailed Census Occupation by Sex And Race/Ethnicity For Worksite Geography" (U.S. Census Bureau, 2018), accessed via https://data.census.gov/cedsci/. AI workforce here is the sum of technical team, product team, and commercial team occupations that are either working directly with or capable of working with AI. Occupation codes (Census EEO codes) for each team are selected based on previous methodology from Diana Gehlhaus and Santiago Mutis, "The U.S. AI Workforce: Understanding the Supply of AI Talent" (Center for Security and Emerging Technology, 2021), https://cset.georgetown.edu/wp-content/uploads/CSET-U.S.-AI-Workforce-Labor-Market-Dynamics.pdf.

[26] Mark Muro and Sifan Liu, "The geography of AI: Which Cities Will Drive the Artificial Intelligence Revolution?" (Brookings, August 2021), https://www.brookings.edu/wp-content/uploads/2021/08/AI-report_Full.pdf.

[27] National Science Foundation, "NSF partnerships expand National AI Research Institutes to 40 states," news release, July 29, 2021, https://www.nsf.gov/news/news_summ.jsp?cntn_id=303176&WT.

[28] Hodan Omaar and Daniel Castro, "Comments to OSTP and NSF on a National AI Research Resource (NAIRR)," September 28, 2021, https://datainnovation.org/2021/09/comments-to-the-ostp-and-nsf-on-a-national-airesearch-resource-nairr/.

[29] Ibid.

[30] Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "AI Education in China and the United States" (CSET, September 2021), https://cset.georgetown.edu/wp-content/uploads/CSET-AI-Education-in-China-and-the-United-States-1.pdf.

[31] Ibid.

[32] Katie Hendrickson et al., "2021 State of computer science education: Accelerating action through advocacy," https://advocacy.code.org/stateofcs.

[33] "7th-9th Online Courses Artificial Intelligence," North Carolina School of Science and Mathematics website, accessed March 15, 2022, https://www.ncssm.edu/summer-programs/accelerator/accelerator-7th-9th/7th-9th-online-courses/artificial-intelligence.

[34] Alia Malik, "New Gwinnett high school brings tech curriculum update," *The Atlanta Journal Constitution*, December 22, 2020, https://www.ajc.com/news/new-gwinnett-high-school-brings-tech-curriculum-update/WEBH6NEN5JEDJPL45HNCOLEBV4/.

[35] Taylor Denman, "What will a theme-cluster look like? A deep dive into Seckinger High School's AI curriculum," *Gwinnett Daily Post*, February 28, 2020 https://www.gwinnettdailypost.com/local/what-will-a-theme-cluster-look-like-a-deep-dive-into-seckinger-high-schools-ai/article_17ccb0ea-5814-11ea-8495-c3b589b5cfbe.html.

[36] United Nations Educational, Scientific and Cultural Organization (UNESCO), "K-12 AI Curricula: A mapping of government-endorsed AI curricula" (Paris: UNESCO, 2022), https://unesdoc.unesco.org/ark:/48223/pf0000380602/PDF/380602eng.pdf.multi.

[37] Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "AI Education in China and the United States."

[38] UNESCO, "K-12 AI Curricula."

[39] Claire Perkins and Kayla Goode, "U.S. AI Summer Camps" (CSET, August 2021), https://cset.georgetown.edu/publication/u-s-ai-summer-camps/.

[40] "Artificial Intelligence and Machine Learning," iDTech website, accessed February 14, 2022, https://www.idtech.com/courses/artificial-intelligence-and-machine-learning.

[41] "Microsoft DigiGirlz," Microsoft website, accessed February 14, 2022, https://www.microsoft.com/en-us/diversity/programs/digigirlz/default.aspx.

[42] "CS First," Google CS website, accessed February 14, 2022, https://csfirst.withgoogle.com/s/en/home.

[43] Cade Metz, "A.I. Researchers Are Making More Than $1 Million, Even at a Nonprofit," *The New York Times*, April 19, 2018, https://www.nytimes.com/2018/04/19/technology/artificial-intelligence-salaries-openai.html.

[44] Natasha Singer, "The Hard Part of Computer Science? Getting Into Class," *The New York Times*, January 24, 2019, https://www.nytimes.com/2019/01/24/technology/computer-science-courses-college.html.

[45] Bryon Spice, "Carnegie Mellon Launches Undergraduate Degree in Artificial Intelligence," *Carnegie Mellon University News*, May 10, 2018, https://www.cmu.edu/news/stories/archives/2018/may/ai-undergraduate-degee.html.

[46] "2018-19 Changes to the CS Major," Swarthmore website, accessed January 31, 2022," https://www.swarthmore.edu/computer-science/2018-19-changes-to-cs-major.

[47] "FAQs About UMD's Computer Science Limited Enrollment Program," University of Maryland website, accessed January 31, 2022, https://cmns.umd.edu/undergraduate/admissions/new-faqs-computer-science-limited-enrollment.

[48] University of Maryland, College Park, Office of the President, "Differential Tuition," accessed March 31, 2022, https://admissions.umd.edu/finance/differential-tuition; "Additional Tuition Information: Supplemental tuition information for business, engineering and computer science majors," University of Maryland website, accessed March 31, 2022, https://www.admissions.umd.edu/costs/DifferentialTuition.php.

[49] Adams Nager and Robert D. Atkinson, "The Case for Improving U.S. Computer Science Education" (ITIF, May 2016), https://www2.itif.org/2016-computer-science-education.pdf.

[50] Ibid.

[51] National Center for Education Statistics website, "What are the most popular majors for postsecondary students?" accessed June 9, 2022, https://nces.ed.gov/fastfacts/display.asp?id=37.

[52] Paul M. Romer, "Should the Government Subsidize Supply or Demand in the Market for Scientists and Engineers?" National Bureau of Economic Research (June 2000), DOI: 10.3386/w7723.

[53] Dahlia Peterson, Kayla Goode, and Diana Gehlhaus, "AI Education in China and the United States."

[54] "AI Across the Curriculum," University of Florida website, accessed March 12, 2022," https://ai.ufl.edu/.

[55] Ibid.

[56] Remco Zwetsloot, "Strengthening the U.S. AI Workforce (CSET, September 2019), https://cset.georgetown.edu/publication/strengthening-the-u-s-ai-workforce/.

[57] Diana Gehlhaus and Ilya Rahkovsky, "U.S. AI Workforce Labor Market Dynamics" (CSET, April 2021).

[58] Ibid.

[59] Murat Krystal, "The upskilling imperative: Building a future-ready workforce for the AI age" (Deloitte, 2020), https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/deloitte-analytics/ca-covid19-upskilling-EN-AODA.pdf.

[60] Alex McFarland, "5 ambitious private sector initiatives preparing the workforce for a future of AI," Ross Dawson blog, accessed May 23, 2020, https://rossdawson.com/futurist/implications-of-ai/5-ambitious-private-sector-initiatives-preparing-the-workforce-for-a-future-of-ai/.

[61] Robert D. Atkinson, "How to Reform Worker-Training and Adjustment Policies for an Era of Technological Change" (ITIF, February 2018), https://www2.itif.org/2018-innovation-employment-workforce-policies.pdf.

[62] The Financial Times Editorial Board, "The great resignation is not going away," *Financial Times*, February 1,2022, https://www.ft.com/content/857bdeba-b61b-4012-ab82-3c9eb19506df.

[63] Robert D. Atkinson, "How a knowledge tax credit could stop decline in corporate training," *The Hill*, September 3, 2015, https://thehill.com/blogs/pundits-blog/finance/235018-how-a-knowledge-tax-credit-could-stop-decline-in-corporate/.

[64] Joseph Kennedy, Daniel Castro, and Robert D. Atkinson, "Why It's Time to Disrupt Higher Education by Separating Learning From Credentialing" (ITIF, August 2016), https://www2.itif.org/2016-disrupting-higher-education.pdf.

[65] National Defense Authorization Act for Fiscal Year 2021, Sec. 5301(d).

[66] Diana Gehlhaus et al., "U.S. AI Workforce: Policy Recommendations" (CSET, October 2021), https://cset.georgetown.edu/publication/u-s-ai-workforce-policy-recommendations.

[67] Joshua New, "Why the United States Needs a National Artificial Intelligence Strategy and What It Should Look Like" (Center for Data Innovation, December 2018), http://www2.datainnovation.org/2018-national-ai-strategy.pdf

[68] Ibid.

[69] Tina Huang, Zachary Arnold, and Remco Zwetsloot, "Most of America's 'Most Promising' AI Startups Have Immigrant Founders" (CSET, October 2020), https://cset.georgetown.edu/publication/most-of-americas-most-promising-ai-startups-have-immigrant-founders/; Tina Huang and Zachary Arnold, "Immigration Policy and the Global Competition for AI Talent" (CSET, June 2020), https://cset.georgetown.edu/publication/immigration-policy-and-the-global-competition-for-ai-talent/.

[70] Based on information from Tina Huang and Zachary Arnold, "Immigration Policy and the Global Competition for AI Talent" (CSET, June 2020).

[71] U.S. Citizen and Immigration Services, "H-1B Electronic Registration Process," last updated March 11, 2022, https://www.uscis.gov/working-in-the-united-states/temporary-workers/h-1b-specialty-occupations-and-fashion-models/h-1b-electronic-registration-process.

[72] John R. Dearie, "An 'entrepreneur visa' can help us keep our competitive edge," *The Hill*, April 10, 2019, https://thehill.com/opinion/immigration/438195-an-entrepreneur-visa-can-help-us-keep-our-competitive-edge/.

[73] Immigration Act of 1990, S.358, 101st Congress (1989–1990).

[74] Stuart Anderson, "Biden Keeps Costly Trump Visa Policy Denying Chinese Grad Students," *Forbes*, August 10, 2021, https://www.forbes.com/sites/stuartanderson/2021/08/10/biden-keeps-costly-trump-visa-policy-denying-chinese-grad-students/?sh=913f1ee36419.

[75] Remco Zwetsloot et al., "Keeping Top AI Talent in the United States" (CSET, December 2019), https://cset.georgetown.edu/wp-content/uploads/Keeping-Top-AI-Talent-in-the-United-States.pdf.

[76] William A. Kandel, "The Employment-Based Immigration Backlog" (Congressional Research Service, March 2020), https://www.everycrsreport.com/files/20200326_R46291_a4731eeb00f39050b6df66d326d0356438414f03.pdf.

[77] Edward Wong and Julian E. Barnes, "U.S. to Expel Chinese Graduate Students With Ties to China's Military Schools," *The New York Times*, May 28, 2020, https://www.nytimes.com/2020/05/28/us/politics/china-hong-kong-trump-student-visas.html.

[78] Daniel Zhang et al., "The AI Index 2022 Annual Report."

[79] Zachary Arnold et al., "Immigration Policy and the U.S. AI Sector" (CSET, September 2019), https://cset.georgetown.edu/wp-content/uploads/CSET_Immigration_Policy_and_AI.pdf.

[80] The White House, "FACT SHEET: Biden-Harris Administration Actions to Attract STEM Talent and Strengthen our Economy and Competitiveness," press release, January 21, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/21/fact-sheet-biden-harris-administration-actions-to-attract-stem-talent-and-strengthen-our-economy-and-competitiveness/.

[81] William A. Kandel, "The Employment-Based Immigration Backlog."

[82] "Indian technology talent is flocking to Canada," *The Economist*, December 22, 2018, https://www.economist.com/business/2018/12/22/indian-technology-talent-is-flocking-to-canada.

[83] Nicole Goodkind, "Immigrant Founders of Multi-Million Dollar Startups Struggle To Remain in the U.S.," *Fortune*, December 11, 2019, https://fortune.com/2019/12/11/immigrant-startup-founders-struggle-to-remain-in-us/.

[84] Somini Sengupta, "Countries Seek Entrepreneurs From Silicon Valley," *The New York Times*, June 5, 2013, https://www.nytimes.com/2013/06/06/technology/wishing-you-and-your-start-up-were-here.html.

[85] Picture taken by Matthew Hertz, https://twitter.com/mattahertz/status/987333483768045574.

[86] Michelle Hackman, "Foreign Entrepreneurs to Gain More Access to Immigration Program," *The Wall Street Journal*, May 10, 2021, https://www.wsj.com/articles/foreign-entrepreneurs-to-gain-more-access-to-immigration-program-11620647100.

[87] Danilo Zak, "Analysis: Immigration Provisions in the America COMPETES Act," *National Immigration Forum*, March 29, 2022, https://immigrationforum.org/article/analysis-immigration-provisions-in-the-america-competes-act/.

[88] Tina Huang, Zachary Arnold, and Remco Zwetsloot, "Most of America's 'Most Promising' AI Startups Have Immigrant Founders."

[89] Tina Huang and Zachary Arnold, "Immigration Policy and the Global Competition for AI Talent."

[90] Jessica Hamzelou, "AI system is better than human doctors at predicting breast cancer," *New Scientist*, January 1, 2020, www.newscientist.com/article/2228752-ai-system-is-better-than-human-doctors-at-predicting-breast-cancer/.

[91] Hodan Omaar and Daniel Castro, "Comments to OSTP and NSF on a National AI Research Resource (NAIRR)."

[92] Hodan Omaar, "How the United States Can Increase Access to Supercomputing" (Center for Data Innovation, December 2020), https://www2.datainnovation.org/2020-how-the-united-states-can-increase-access-to-supercomputing.pdf.

[93] "Introducing Meta's Next-Gen AI Supercomputer," Meta website, last modified January 24, 2022, https://about.fb.com/news/2022/01/introducing-metas-next-gen-ai-supercomputer/.

[94] "Request for Information (RFI) on an Implementation Plan for a National Artificial Intelligence Research Resource," Federal Register, July 23, 2021, https://www.federalregister.gov/documents/2021/07/23/2021-15660/request-for-information-rfi-on-an-implementation-plan-for-a-national-artificial-intelligence.

[95] "About the Task Force," National AI Research Resource website, accessed April 6, 2022, https://www.ai.gov/nairrtf/.

[96] EuroHPC website, accessed September 17, 2021, https://eurohpc-ju.europa.eu/.

[97] Common European Data Spaces website, accessed April 4, 2022, http://dataspaces.info/common-european-data-spaces/#page-content.

[98] Hodan Omaar, "Innovation Wars: Episode AI – The Techlash Strikes Back" (Center for Data Innovation, January 2022), https://datainnovation.org/2022/01/innovation-wars-episode-ai-the-techlash-strikes-back/.

[99] Ibid.

[100] Khari Johnson, "Why the OECD wants to calculate the AI compute needs of national governments," *VentureBeat*, January 26, 2021, https://venturebeat.com/2021/01/26/why-the-oecd-wants-to-calculate-the-ai-compute-needs-of-national-governments/.

[101] Hodan Omaar, "Comments to OSTP and NSF on a National AI Research Resource (NAIRR)."

[102] Eric Egan, "Federal IT Modernization Needs a Strategy and More Money" (ITIF, May 2022), https://www2.itif.org/2022-federal-it-modernization.pdf.

[103] Cade Metz, "A.I. Researchers Are Making More Than $1 Million, Even at a Nonprofit."

[104] AI Training Act of 2021, S.2551, 117th Congress (2021–2022).

[105] Robert D. Atkinson, Daniel Castro, and Stephen Ezell, "Enabling Customer-Driven Innovation in the Federal Government" (ITIF, July 2017), https://www2.itif.org/2017-federal-innovation-agenda.pdf.

[106] Pablo Fuentes Nettel et al., "Government AI Readiness Index 2021" (Oxford Insights, January 2022), https://www.oxfordinsights.com/government-ai-readiness-index2021.

[107] Peter Viechnicki and William D. Eggers, "How much time and money can AI save government?" Deloitte website, April 26, 2017, https://www2.deloitte.com/us/en/insights/focus/cognitive-technologies/artificial-intelligence-government-analysis.html.

[108] "CoE and GSA AI Highlight," General Services Administration YouTube video (8:13), https://www.youtube.com/watch?v=ryclBwyjBFg.

[109] Robert D. Atkinson, Daniel Castro, and Stephen Ezell, "Enabling Customer-Driven Innovation in the Federal Government."

[110] Joshua New and Daniel Castro, "How Policymakers Can Foster Algorithmic Accountability" (Center for Data Innovation, May 21, 2018), http://www2.datainnovation.org/2018-algorithmic-accountability.pdf.

[111] Daniel Castro and Joshua New, "Comments to NIST on AI Standards" (Center for Data Innovation, May 2019), https://www2.datainnovation.org/2019-nist-ai-standards.pdf.

[112] Riya Anandwala and Danielle Cassagnol, "CTA Launches First-Ever Industry-Led Standard for AI in Health Care," CTA press release, February 25, 2020, https://www.cta.tech/Resources/Newsroom/Media-Releases/2020/February/CTA-Launches-First-Ever-Industry-Led-Standard.

[113] Onnx website, accessed March 4, 2022, https://onnx.ai/about.html and https://www.khronos.org/about/.

[114] National Institute of Standards and Technology (NIST), "Facial Recognition Technology (FRT)" (testimony before Committee on Homeland Security), February 6, 2020, https://www.nist.gov/speech-testimony/facial-recognition-technology-frt-0.

[115] "Maintaining American Leadership in Artificial Intelligence," Federal Register, February 1, 2019, https://www.federalregister.gov/documents/2019/02/14/2019-02544/maintaining-american-leadership-in-artificial-intelligence.

[116] NIST website on Fundamental AI, accessed March 6, 2022, https://www.nist.gov/fundamental-ai.

[117] Consolidated Appropriations Act of 2021, H.R.133, 116th Congress (2019–2020).

[118] Nigel Cory, "Comments to the U.S. Commerce Department on the Indo-Pacific Economic Framework" (ITIF, March 2022), https://www2.itif.org/2022-indo-pacific-economic-framework.pdf.

[119] Ibid

[120] European Commission, Artificial Intelligence Act, Article 41.

[121] Brian DeLacey et al., "Government Intervention in Standardization: The Case of Wapi," *SSRN* (September 2006), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=930930.

[122] Matt Sheehan et al., "Three Takeaways From China's New Standards Strategy" (Carnegie Endowment for International Peace, October 2021), https://carnegieendowment.org/2021/10/28/three-takeaways-from-china-s-new-standards-strategy-pub-85678.

[123] U.S. Department of Justice, "Comments on the U.S. Standards Strategy," September 8, 2020, https://www.justice.gov/atr/page/file/1314196/download.

[124] Nigel Cory, "Comments to the U.S. Commerce Department on the Indo-Pacific Economic Framework."

[125] Matt Sheehan et al., "Three Takeaways From China's New Standards Strategy."

[126] United Kingdom government, "New UK initiative to shape global standards for Artificial Intelligence," press release, January 12, 2022, https://www.gov.uk/government/news/new-uk-initiative-to-shape-global-standards-for-artificial-intelligence.

[127] Robert D. Atkinson et al., "President-Elect Biden's Agenda on Technology and Innovation Policy" (ITIF, November 2020), https://www2.itif.org/2020-biden-tech-innovation-policy.pdf.

[128] Algorithmic Accountability Act of 2022, H.R.6580, 117th Congress (2021–2022).

[129] Daniel Zhang et al., "The AI Index 2022 Annual Report."

[130] Ibid.

[131] Daniel Castro and Michael McLaughlin, "Ten Ways the Precautionary Principle Undermines Progress in Artificial Intelligence" (ITIF, February 2019), https://itif.org/publications/2019/02/04/ten-ways-precautionary-principle-undermines-progress-artificial-intelligence.

[132] Ibid

[133] U.S. Office of Management and Budget, "Memorandum for the Heads of Executive Departments and Agencies," January 2020, https://www.whitehouse.gov/wp-content/uploads/2020/01/Draft-OMB-Memo-on-Regulation-of-AI-1-7-19.pdf.

[134] Hodan Omaar, "Biden Should Avoid Unwinding OMB's Rules for AI Regulation" (Center for Data Innovation, January 2021), https://datainnovation.org/2021/01/biden-should-avoid-unwinding-ombs-rules-for-ai-regulation/.

[135] U.S. Office of Management and Budget, "Memorandum for the Heads of Executive Departments and Agencies."

[136] Elisa Jillson, "Aiming for truth, fairness, and equity in your company's use of AI," Federal Trade Commission (FTC) blog, https://www.ftc.gov/business-guidance/blog/2021/04/aiming-truth-fairness-equity-your-companys-use-ai.

[137] AI Now Institute website, accessed March 1, 2022, https://ainowinstitute.org/about.html.

[138] Eric Lander and Alondra Nelson, "Americans Need a Bill of Rights for an AI-Powered World," *Wired*, October 8, 2021, https://www.wired.com/story/opinion-bill-of-rights-artificial-intelligence/.

[139] Joshua New and Daniel Castro, "How Policymakers Can Foster Algorithmic Accountability" (Center for Data Innovation, May 2018), https://www2.datainnovation.org/2018-algorithmic-accountability.pdf.

[140] Joshua New, "Why the United States Needs a National Artificial Intelligence Strategy and What It Should Look Like."

[141] Ibid.

[142] Nigel Cory and Daniel Castro, "Comments to the U.S. Patent and Trademark Office on the Impact of Artificial Intelligence on Intellectual Property Law and Policy" (ITIF, January 2020), https://www2.itif.org/2020-ustpo-ip-ai.pdf.

[143] Ibid.

[144] "AI As A Patent Inventor – An Update From South Africa And Australia," JDSUPRA, September 9, 2021, https://www.jdsupra.com/legalnews/ai-as-a-patent-inventor-an-update-from-2776042/.

[145] U.S. Patent and Trademark Office (USPTO), "Public Views on Artificial Intelligence and Intellectual Property Policy" (October 2020), https://www.uspto.gov/sites/default/files/documents/USPTO_AI-Report_2020-10-07.pdf.

[146] Ibid.

[147] USPTO, "Inventing AI: Tracing the diffusion of artificial intelligence with U.S. patents" (October 2020), https://www.uspto.gov/sites/default/files/documents/OCE-DH-AI.pdf.

[148] Jordan R. Jaffe et al., "The Rising Importance of Trade Secret Protection for AIRelated Intellectual Property," blog post, https://www.quinnemanuel.com/media/wi2pks2s/the-rising-importance-of-trade-secret-protection-for-ai-related-intellec.pdf.

[149] Jessica M. Meyers, "Artificial Intelligence and Trade Secrets," American Bar Association website (February 2019), https://www.americanbar.org/groups/intellectual_property_law/publications/landslide/2018-19/january-february/artificial-intelligence-trade-secrets-webinar/.

[150] NSCAI Final Report.

[151] Nigel Cory and Luke Dascoli, "How Barriers to Cross-Border Data Flows Are Spreading Globally, What They Cost, and How to Address Them" (ITIF, July 2021), https://itif.org/publications/2021/07/19/how-barriers-cross-border-data-flows-are-spreading-globally-what-they-cost.

[152] Daniel Castro, "The False Promise of Data Nationalism" (ITIF, December 2013), https://www2.itif.org/2013-false-promise-data-nationalism.pdf.

[153] Joshua New, "Why the United States Needs a National Artificial Intelligence Strategy and What It Should Look Like."

[154] Australia Department of Foreign Affairs and Trade, "CPTPP outcomes: Trade in the digital age," https://www.dfat.gov.au/trade/agreements/in-force/cptpp/outcomes-documents/Pages/cptpp-digital.

[155] Nigel Cory, "U.S. Options to Engage on Digital Trade and Economic Issues in the Asia-Pacific" (ITIF, February 2022), https://itif.org/publications/2022/02/08/us-options-engage-digital-trade-and-economic-issues-asia-pacific.

[156] "United States-Mexico-Canada Agreement Text," Office of the United States Trade Representative, Accessed February 26, 2022, https://ustr.gov/trade-agreements/free-trade-agreements/united-states-mexico-canada-agreement

[157] Ibid.

[158] Nigel Cory, Daniel Castro, and Ellysse Dick, "'Schrems II': What Invalidating the EU-U.S. Privacy Shield Means for Transatlantic Trade and Innovation" (ITIF, December 2020), https://itif.org/sites/default/files/2020-privacy-shield.pdf.

[159] Ibid.

[160] Nigel Cory, "Comments to the U.S. Commerce Department on the Indo-Pacific Economic Framework."

[161] Benjamin Mueller, "As the EU Begins to Fight for Liberalism in Earnest, Its Technology Policy Must Catch Up" (Center for Data Innovation, March 2022), https://datainnovation.org/2022/03/as-the-eu-begins-to-fight-for-liberalism-in-earnest-its-technology-policy-must-catch-up/.

[162] Saif M. Khan and Alexander Mann, "AI Chips: What They Are and Why They Matter" (CSET, April 2020), https://cset.georgetown.edu/publication/ai-chips-what-they-are-and-why-they-matter.

[163] Daniel Castro and Michael McLaughlin, "Who Is Winning the AI Race: China, the EU, or the United States? — 2021 Update" (Center for Data Innovation, January 2021), https://datainnovation.org/2021/01/who-is-winning-the-ai-race-china-the-eu-or-the-united-states-2021-update.

[164] Saif M. Khan and Alexander Mann, "AI Chips: What They Are and Why They Matter."

[165] Stephen Ezell, "Moore's Law Under Attack: The Impact of China's Policies on Global Semiconductor Innovation" (ITIF, February 2021), https://itif.org/publications/2021/02/18/moores-law-under-attack-impact-chinas-policies-global-semiconductor.

[166] Ibid.

[167] Stephen Ezell, "An Allied Approach to Semiconductor Leadership" (ITIF, September 2020), https://itif.org/publications/2020/09/17/allied-approach-semiconductor-leadership.

[168] Stephen Ezell and Caleb Foote, "How Stringent Export Controls on Emerging Technologies Would Harm the U.S. Economy" (ITIF, May 2019), https://www2.itif.org/2019-export-controls.pdf.

[169] Carrick Flynn, "Recommendations on Export Controls for Artificial Intelligence" (CSET, February 2020), https://cset.georgetown.edu/wp-content/uploads/Recommendations-on-Export-Controls-for-Artificial-Intelligence.pdf.

[170] Stephen Ezell and Caleb Foote, "How Stringent Export Controls on Emerging Technologies Would Harm the U.S. Economy."