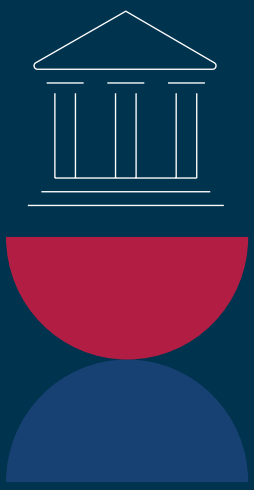
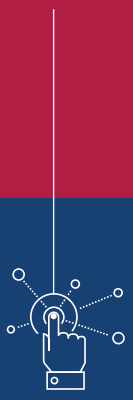
SPECIAL COMPETITIVE STUDIES PROJECT

ECONOMY

Interim Panel Report

November 2022





Contributors

The Economy Panel Interim Panel Report (IPR) is the third of six interim reports from the overall work that the Special Competitive Studies Project (SCSP) has conducted over the past year and that was summarized in our Mid-Decade Challenges to National Competitiveness report published on 12 September 2022.

ECONOMY PANEL INTERIM PANEL REPORT

Restoring the Sources of Techno-Economic Advantage

Executive Summary

America faces a generational competition with the People's Republic of China (PRC), and technology is at the center. As the techno-economic competition intensifies, the United States possesses massive economic advantages, including a world-class innovation ecosystem, a highly productive workforce, and the world's largest and most liquid capital markets. But warning lights are flashing. Growing talent gaps in key sectors, slowing productivity growth, the erosion of U.S. manufacturing, and China's distortionary industrial policies have raised questions as to whether the United States will remain the world's technological and economic leader. America and its allies and partners are also experiencing significant supply chain vulnerabilities for critical technology inputs.

To secure its economic foundation, the United States needs a techno-industrial strategy (TIS) – a **public-private initiative** to shore up systemic factors across key technology sectors. The TIS should aim to boost technology diffusion across the market – generating productivity growth and prosperity for all Americans, filling economic and national security gaps, and strengthening democratic advantage by acting in concert with allies and partners. A TIS should have five pillars:

Production: Secure access to critical technology inputs

- Accelerate stockpiling efforts for rare earth minerals and permanent magnets;
- Drive localization and friendshoring of advanced battery supply chains; and
- Launch microelectronics moonshots and create a large investment 'fund of funds' that unlocks private capital.

Pipes: Invest in America's digital infrastructure

- Create a National Strategy for Digital Infrastructure;
- Win the race for 5G and 6G applications, including smart factories and smart cities; and
- Enhance cybersecurity for the hardware layer and create an Open Source Security Center.

People: Build America's future workforce

- Invest in education and apprenticeship programs to upgrade America's tech workforce;
- Upgrade immigration policies to attract high-skill talent; and
- Use automation and reskilling to benefit workers.

Project: Extend U.S. financial leadership into the digital age

- Maintain American financial leadership by fostering innovation in financial technologies;
- Establish a National Security Commission on Digital Finance; and
- Update the U.S. Government's trade and investment promotion toolkit.

Pushback: Counter Beijing's techno-economic malpractice

- Screen and, as needed, block investment flows and PRC access to U.S. market in sectors that enable China to undermine America's national security and technological advantage;
- Modernize export controls for an era of emerging technologies and create new export control regime with key allies and partners; and
- Prepare sanctions packages for a potential military contingency.

Introduction

Strong economic foundations enable societies to thrive and provide the resources to sustain technology leadership, craft a competitive foreign policy, and project military power. A productive and growing economy means better livelihoods for ordinary Americans. But U.S. leadership in key technology sectors is eroding, raising questions as to whether the United States can remain competitive in the development and production of emerging technologies and guarantee continued gains in quality of life. Meanwhile, for the first time in modern history, the United States faces an autocratic rival with an economy comparable to its own in size.[1] While the United States remains the world's largest economy in market terms, China's state-directed economic model has directly challenged U.S. economic leadership. Beijing has leveraged a range of distortionary policies to undermine American firms – and those of other democratic market economies – while strengthening PRC national champions.

Sources of Techno-Economic Advantage

America Holds Massive Economic Advantages

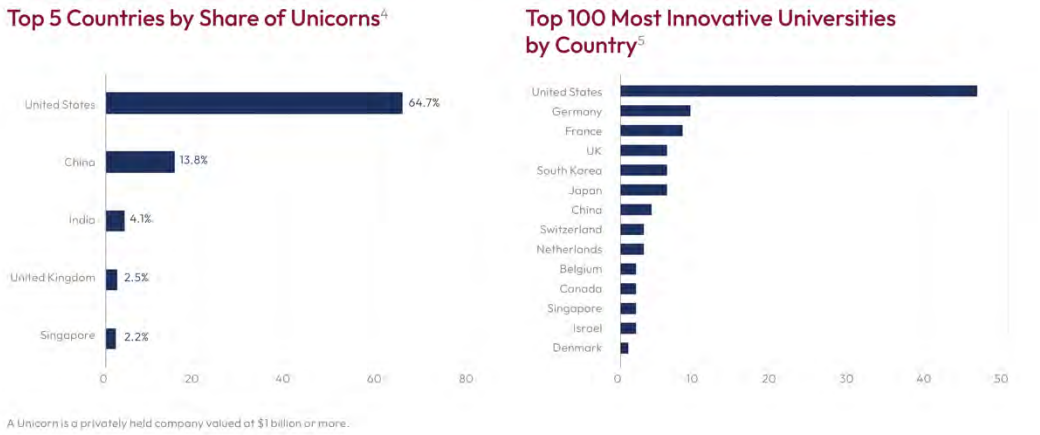
Despite these concerns, the economic competition should be America's to lose.[2] The United States has the largest economy in the world and boasts numerous other advantages, including:

- *A world-class innovation ecosystem.* The United States has the world's most innovative university network, a vibrant start-up ecosystem, and a lead in patent quality.[3] America's innovation ecosystem attracts talent from around the world, including China.

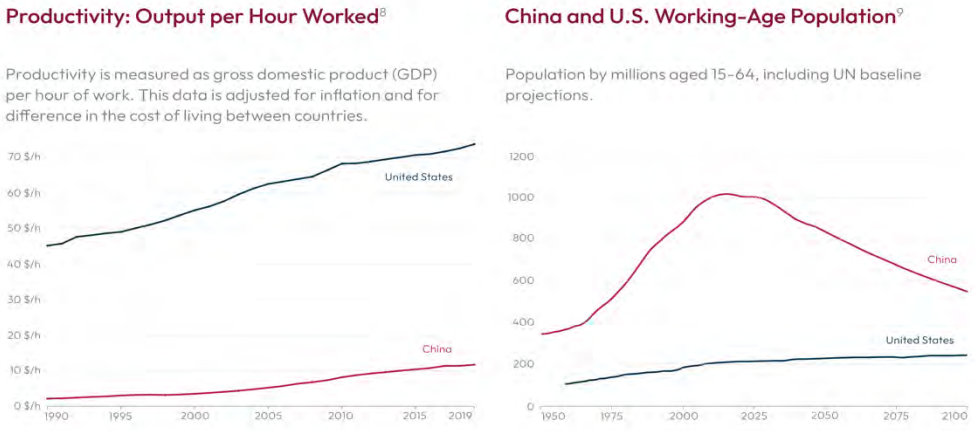
[1] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited (2022) *(SCSP-commissioned work product).* As of 2021, China's GDP in market terms was approximately 75 percent that of the United States. See Gross Domestic Product (GDP) at Current Prices in China from 1985 to 2021 with Forecasts Until 2027, Statista (last accessed 2022); Gross Domestic Product, Fourth Quarter and Year 2021 (Second Estimate), Bureau of Economic Analysis (2022). Even at its height, the Soviet Union's economy constituted only a third of U.S. GDP. See Andrew Krepinevich Jr., Finding Strength in Decline, Hudson Institute (2020).

[2] See Appendix A of this report for a comparative assessment of the U.S. and PRC economies across what economists refer to as "factors of production" – land, labor, capital, and innovation.

[3] David M. Ewalt, The World's Most Innovative Universities 2019, Reuters (2019); Global Innovation Index 2021, World Intellectual Property Organization (2021); Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 32-33 (2022) *(SCSP-commissioned work product)*. Other advantages include world-class labs and intellectual property (IP) protections, although the U.S. IP regime needs to be updated to address emerging technologies like AI. For steps the United States should take to update its IP regime, see Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 74-75 (2022).



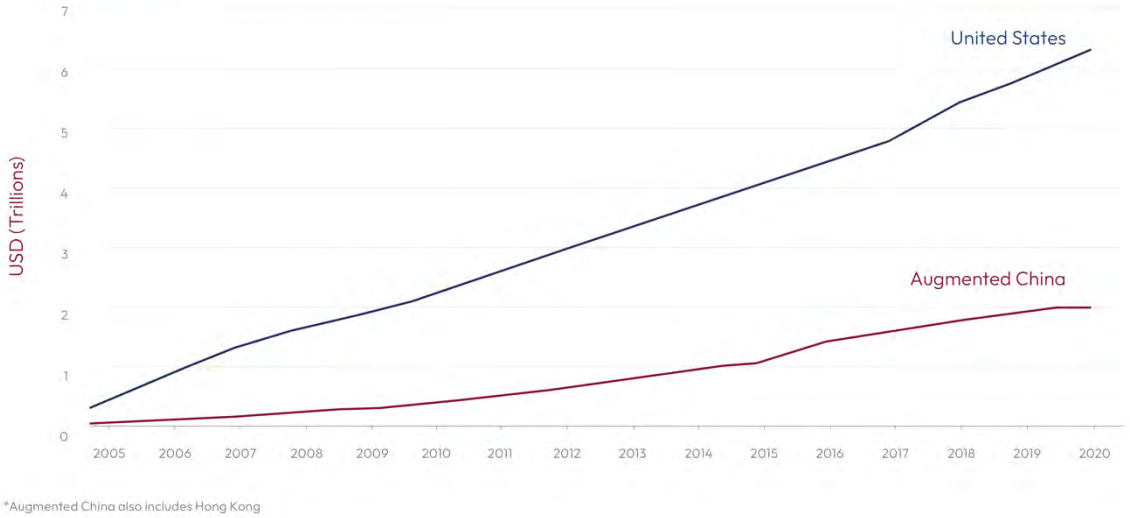
- *A highly productive and growing labor force.* American workers maintain a high level of productivity, and the U.S. population is growing – in part owing to immigration.[6] China's population, on the other hand, is peaking and will decline over the coming decades. This trend, together with other economic headwinds, is bringing the PRC's era of rapid growth to an end.[7]



[4] Gerard J. Tellis, Startup Index of Nations & Regions, USC Marshall School of Business (last accessed 2022).
[5] David M. Ewalt, The World's Most Innovative Universities 2019, Reuters (2019).
[6] The United States can make up for its demographic shortfalls in part via immigration, as it consistently ranks as the most attractive destination for potential migrants. See Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited (2022) *(SCSP-commissioned work product)*; Neli Esipova, et al., More Than 750 Million Worldwide Would Migrate If They Could, Gallup (2018). For labor productivity comparison, see Statistics on Labour Productivity, International Labor Organization (last accessed 2022).
[7] Daniel Rosen, The Age of Slow Growth in China, Foreign Affairs (2022). Additional economic headwinds include high corporate and local government debt, an overleveraged real estate sector, and, more recently Xi Jinping's zero-COVID policies and crackdown on China's technology sector.
[8] Productivity: Output Per Hour Worked, Our World in Data (last accessed 2022).
[9] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 32-33 (2022) *(SCSP-commissioned work product)*.

- *The world's largest and most liquid financial markets*. America's financial leadership is unparalleled: the value of its equity markets totals some $52.2 trillion (as of July 2022),[10] nearly quadruple the value of the China's. U.S. foreign direct investment (FDI) powers global growth, and the United States has out-invested the PRC by three to one since 2005.[11]

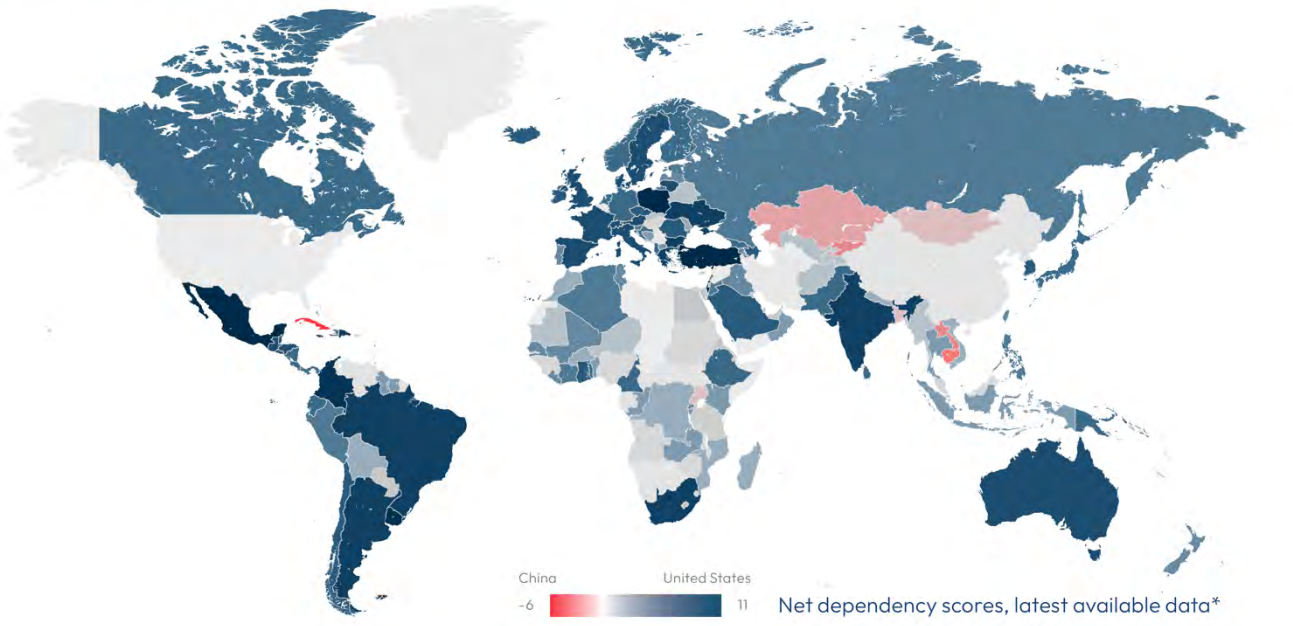
Global Foreign Direct Investment*[12]



*Augmented China also includes Hong Kong

[10] 2022 Capital Markets Fact Book, SIFMA at 7 (2022).
[11] The United States has out-invested China by approximately three to one in terms of FDI since 2005, based on data from Fathom Financial Consulting's Capital Flows Tracker, a database that monitors China's financial footprint (including Hong Kong) since 2005 by combining a range of datasets. The database disaggregates capital flows into M&A and greenfield investment and for each deal includes company, country, sector, geo-location, deal status and deal value – including Fathom's estimates where the information is not publicly available. See Erik Britton, Beware of People Bearing Gifts, Fathom Financial Consulting Limited at footnote 1 (2022).
[12] Fathom Financial Consulting Limited (2022) *(SCSP-commissioned work product)*.

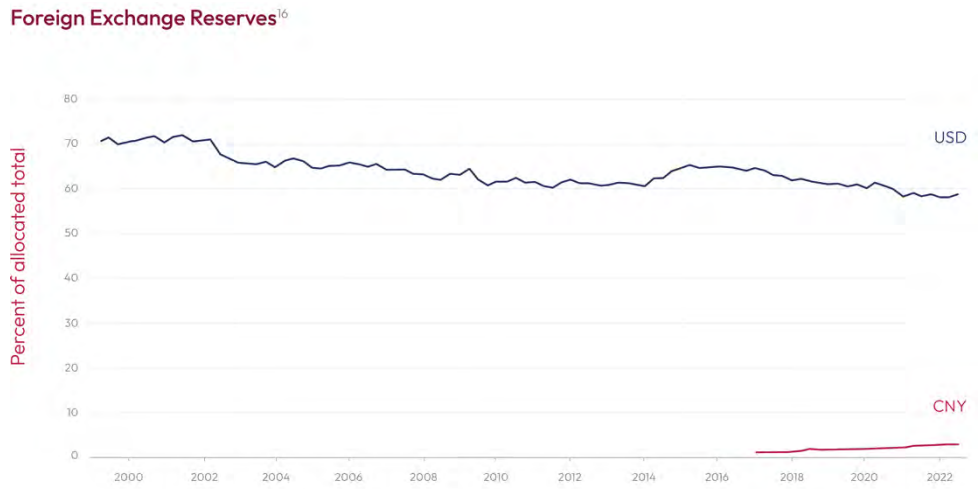
Global Financial Dependency on the U.S. and China[13]



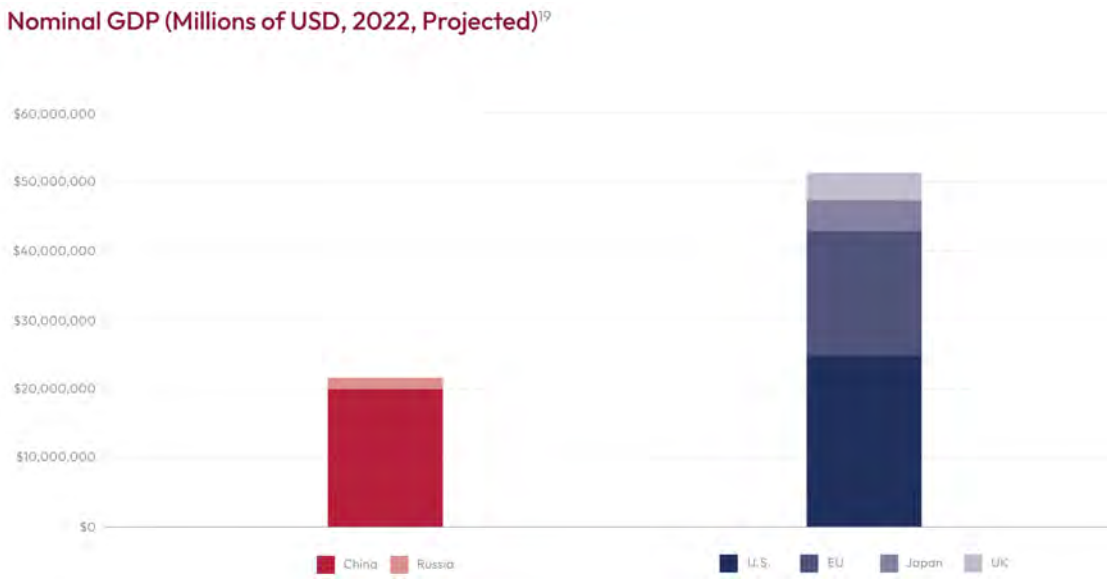
*Scores are created as the aggregation of separate scores across multiple variables including: bilateral foreign direct investment (both inbound and outbound); aid flows; flows of remittances; and correlations in exchange rate movements. Variable-level scores are calculated by assigning the value of 1 to the hub (i.e., the USA or China) with which a country has the closest ties and a value of zero to the other hub

- *The dollar's status as the leading global reserve currency.* The dollar's reserve currency status benefits all Americans in the form of lower interest rates relative to global peers.[14] China's currency, the renminbi (RMB), accounts for less than three percent of global reserves.[15]

[13] Fathom Financial Consulting Limited (2022) *(SCSP-commissioned work product).*
[14] Since the USD became the world's reserve currency in the mid-20th century, the United States has, by one estimate, accrued trillions of dollars' worth of seigniorage, benefitting every American in the form of lower interest rates relative to global peers. SCSP staff engagement with Fathom Financial Consulting Limited (May 2022); Fathom estimate based on the difference in returns on U.S. external assets and external liabilities from the 1960s until the present.
[15] Currency Composition of Official Foreign Exchange Reserves, International Monetary Fund (last accessed 2022).



- *Unrivaled network of allies and partners.* America enjoys close security and economic relationships with dozens of treaty allies, an advantage which China lacks. Combined, democracies account for more than 60 percent of global Gross Domestic Product (GDP).[17] Democracies provide significant markets and capital and are more innovative than their autocratic rivals.[18]



[16] Fathom Financial Consulting Limited (2022) *(SCSP-commissioned work product)*.
[17] Tom Orlick, et al., A Third of the Global GDP is Now Generated by Non-Democracies, Bloomberg (2022).
[18] Global Innovation Index 2022, World Intellectual Property Organization (2022). Fathom's literature review found that democracies tend to be more innovative than their autocratic counterparts. Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 46 (2022) *(SCSP-commissioned work product)*.
[19] World Economic Outlook Database, U.S. International Monetary Fund (2022).

...But Warning Lights Are Flashing

Despite numerous U.S. advantages,[20] America's techno-economic engine is under strain. Key technological and economic indicators suggest that U.S. advantages are slipping:

The United States has experienced strategic surprise in key "battleground" technologies. U.S. technological leadership has become contested. America missed strategic opportunities in 5G wireless technology, microelectronics, and artificial intelligence (AI), and national-level efforts were needed to prevent the United States from falling behind.[21] China's industrial policy playbook has enabled it to dominate the market for drones, high-capacity batteries, critical minerals and permanent magnets, solar panels, wind turbines, and shipbuilding.[22]

[20] Other U.S. advantages include trusted legal and regulatory institutions that provide benefits such as contract sanctity and a diversified and resilient economy with a track record of bouncing back from downturns.
[21] Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 19-20 (2022).
[22] Rick Switzer & David Feith, China Hit Some Bumps on Its Road to Semiconductor Dominance, Wall Street Journal (2022); see also Gerard DiPippo, et al., Red Ink: Estimating Chinese Industrial Policy Spending in Comparative Perspective, Center for Strategic and International Studies (2022).

America's productivity growth has slowed for nearly two decades. Increasing productivity, the measure of economic output per worker or machine in an economy, is central to boosting economic growth.[23] Productivity growth often signals that an economy is reaping the benefits of innovation – since the adoption of better technology helps workers do their jobs more effectively – and offers the only pathway for advanced economies to enhance standards of living over the long term.[24] But since 2004, America's productivity growth has slowed.[25] Lagging growth suggests that, despite breakthroughs in emerging technologies like AI and 5G networks, these technologies have yet to fully diffuse across the market and translate into economic gains.[26] Despite efforts to expand broadband access, rural residents still trail other Americans in broadband adoption.[27]

American manufacturing has withered, leaving the United States exposed to supply shocks for critical technology inputs. According to the U.S. Science and Technology Council, "production and employment have fallen sharply in several advanced manufacturing industries. The trade balance in advanced technology products – a traditional strength of the United States – shifted from surplus to deficit starting in 2001, with a trade deficit of $197 billion in 2021."[28] Corresponding declines in manufacturing jobs depressed U.S. employment rates, working hours, and pay,[29] as workers who left manufacturing lost an estimated 19 percent of wages between 2000 and 2018.[30] A variety of factors are to blame, from a lack of access to capital for 'deep tech'[31] to the distortionary effects of PRC industrial policy and broader globalization trends.[32] This erosion has created dependencies on East Asia for critical technology inputs like microelectronics,

[23] Robert D. Atkinson, Competitiveness, Innovation and Productivity: Clearing Up The Confusion, Information Technology & Innovation Foundation (2013).
[24] Gregory Tassey, The Economic Rationales and Impacts of Technology-Based Economic Development Policies, Economic Policy Research Center at 1-5 (2018).
[25] Even though American workers are among the most productive in the world, overall productivity *growth* for the economy has slowed in the United States, other advanced economies, and in China. Economists are not in agreement as regards to why. Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 14 (2022) *(SCSP-commissioned work product).*
[26] Erik Brynjolfsson, et al., How to Solve the Puzzle of Missing Productivity Growth, Brookings (2021).
[27] Emily A. Vogels, Some Digital Divides Persist Between Rural, Urban and Suburban America, Pew Research Center (2021).
[28] National Strategy for Advanced Manufacturing, The White House at 2 (2022). According to the document, "employment in the manufacturing sector began declining in the late 1990s; in the decade from 2000 to 2010, one-third of U.S. manufacturing workers (nearly six million people) lost their jobs. Fewer than two million of those jobs have been regained." Roughly 60 percent of U.S. manufacturing job losses between 2001 and 2019 can be traced to the "China shock," a period of heightened import competition from the PRC. David Autor, et al., The China Shock and Its Enduring Effects, Stanford Center on China's Economy & Institutions (2022).
[29] Kerwin Kofi Charles, et al., The Transformation of Manufacturing and the Decline of U.S. Employment, National Bureau of Economic Research at 2-3 (2018).
[30] Jeff Ferry, Manufacturing Jobs and Income Decline, Coalition for a Prosperous America (2019).
[31] 'Deep tech' refers to companies and sectors that attempt to solve engineering challenges and often develop physical products. Examples include advanced semiconductors, biotechnology, robotics, and quantum information science. See Antoine Gourévitch, et al., Deep Tech and the Great Wave of Innovation, Boston Consulting Group (2021). In 2021, venture capital investment in software outweighed VC investment in hardware by roughly 10 to 1. Yifei Huang, Software Is the Tech You Date, But Hardware Is the Tech You Marry, London Business School (2022). See also Josh Lerner & Ramana Nanda, Venture Capital's Role in Financing Innovation: What We Know and How Much We Still Need to Learn, Journal of Economic Perspectives at 245-248 (2020).
[32] Rick Switzer & David Feith, China Hit Some Bumps on Its Road to Semiconductor Dominance, Wall Street Journal (2022).

critical minerals, and high-capacity batteries, posing risks to both economic and national security. In 2021, semiconductor shortages shaved an estimated one percent from U.S. GDP.[33]

The United States has lagged behind China in rolling out cutting-edge digital infrastructure and lacks a national strategy to harness data for economic advantage and societal benefit. China rolled out 5G infrastructure and radio spectrum[34] more quickly than the United States, boasts faster network speeds,[35] and is pressing PRC firms to develop 5G enterprise applications – an estimated multi-trillion dollar market by 2030.[36] Overseas, Beijing is continuing to advance its Digital Silk Road by building critical network and computing infrastructure in countries around the world.[37] Beijing's economic theorists have framed data as a "factor of production" – on par with land, labor, and capital – and Party leaders have created policies and regulatory frameworks designed to harness data for economic benefit.[38] While the United States is accelerating its 5G investment[39] and enjoys the world's best data and cloud firms,[40] it lacks a national-level strategy to harness digital infrastructure and data for competitive and societal advantage.

America faces a global competition for talent, and shortages of skilled workers and lagging digital literacy pose a threat to U.S. competitiveness. The number of jobs requiring digital skills is growing, but America is falling behind in supplying the necessary tech talent. By 2030, it is estimated that up to 2.1 million U.S. manufacturing jobs could go unfilled due to a growing digital skills talent gap.[41] This gap is likely to increase, given estimates by the Bureau of Labor Statistics that employment in computer and information technology occupations will increase 15 percent between 2021 and 2031.[42]

Advances in financial technology (fintech) and foreign government attempts to reduce use of the dollar have called into question the durability of America's status as global financial leader. The PRC is systematically using new fintech innovations to build payments systems that could be easier for its trading partners to use and harder for the United States to sanction. Beijing has begun rolling out its digital currency, the e-CNY, domestically. Combined, the PRC's digital currency and payments system together might appeal to users in other countries for their ease of use, cheaper costs, and wealth of data. Since capital controls can be programmed into the digital currency itself, fintech could enable both the yuan's internationalization and the PRC's rise in influence in global finance and technology standards.

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[33] Jordan Fabian, Biden Aide Deese Says Semiconductor Shortage Cost 1% of U.S. GDP, Bloomberg (2022).
[34] Updated Study of 5G Spectrum Availability Underscores Need for U.S. Action to Expand Licensed Spectrum Pipeline, CTIA (2022).
[35] Global Median Speeds August 2022, Speedtest Global Index (last accessed 2022).
[36] Ferry Grijpink, et al., Connected World: An Evolution in Connectivity Beyond the 5G Revolution, McKinsey Global Institute at iv (2020); '全国移动网络质量监测报告：2022年第一季度', China Academy of Information and Communications Technology (2022).
[37] Jon Hillman, The Digital Silk Road: China's Quest to Wire the World and Win the Future, Harper Business (2021).
[38] See Emily de La Bruyère, A New Type of Geopolitical Power: China's Competitive Strategy for the Digital Revolution, National Bureau of Asian Research (2022).
[39] Francesco Rizzato, How the 5G Experience Has Improved Across 50 US States and 300 Cities, Opensignal (2022).
[40] Mark Haranas, Top Cloud Market Share Leaders: AWS, Microsoft, Google Lead Q2 2022, CRN (2022).
[41] Paul Wellener, et al., Creating Pathways for Tomorrow's Workforce Today, Deloitte Insights & The Manufacturing Institute at 6 (2021).
[42] Computer and Information Technology Occupations, U.S. Bureau of Labor Statistics (last accessed 2022).

China's aggressive pursuit of techno-economic dominance has undercut American industry and harmed national security. U.S. policy frameworks have struggled to keep up with a determined rival's evolving technology strategy. The PRC benefits from access to America's technology, capital, and expertise and employs aggressive policies to target strategic industries in the United States and other advanced economies, undermining their ability to innovate and produce prosperity.[43] As part of a technology indigenization strategy that Beijing has pursued for years and backed with well-resourced industrial policies, the PRC is either acquiring or eliminating competitors in advanced economies, leaving the United States and its allies and partners dependent on PRC firms for critical technology inputs and products.[44]

Toward a Techno-Industrial Strategy

To regain advantage, the United States must adopt a techno-industrial strategy. Through targeted intervention in key sectors, the government can partner with the private sector to unleash a new wave of innovation,[45] boosting growth by clearing the runway for emerging technologies to diffuse across the economy. A TIS would synthesize existing policy efforts with new ideas to provide a game-changing boost to America's technology and innovation ecosystem and economic foundation. The past few months have seen significant policy momentum on this front: the Biden administration has called for a "modern American industrial strategy" based on the idea that "strategic public investments are essential to achieving the full potential of our nation's economy."[46] Congress passed the CHIPS and Science Act and the Inflation Reduction Act

[43] Robert D. Atkinson, Innovation Drag: China's Economic Impact on Developed Nations, Information Technology & Innovation Foundation (2020).

[44] China's indigenous innovation strategy has roots dating back decades, to The Long-term Plan for the Development of Science and Technology for 1956–1967. This ten-year plan began Beijing's decades-long quest to compete with and eventually surpass the United States in emerging technologies. See Zuoyue Wang, The Chinese Developmental State During the Cold War: The Making of the 1956 Twelve-Year Science and Technology Plan, History and Technology (2015). Beginning in 1959, this plan targeted atomic energy, jet propulsion and rocket technologies, radio electronics and its new applications, mechanization and automation of production processes, semiconductor technology, and computing technology – all key areas of technology competition between the United States and the PRC to this day. Another iteration of this national strategy was released in 2006. See National Medium- and Long-term Program for Science and Technology Development, The State Council, The People's Republic of China (2006). Beijing subsequently doubled down on these policies with lavishly-resourced efforts to replace imports of advanced technology with domestic production and boost China's global market share, eliminating foreign competition along the way. Gerard DiPippo, et al., Red Ink: Estimating Chinese Industrial Policy Spending in Comparative Perspective, Center for Strategic and International Studies (2022); Rick Switzer & David Feith, China Hit Some Bumps on Its Road to Semiconductor Dominance, Wall Street Journal (2022). Examples of key policy documents include the 2010 Strategic and Emerging Industries plan, Made in China 2025, and "dual circulation" policies in the 14th Five-Year Plan, which seek to "transfer and localize foreign capabilities in China and maintain access to global markets wherever possible – including for key inputs, technology, and exports – to develop China's capabilities." Under dual circulation, China's non-reciprocal approach to trade has intensified, with restrictions to China's market increasing even as PRC firms expand overseas. See Karen Sutter, China's 14th Five-Year Plan: A First Look, Congressional Research Service (2021).

[45] Boosting innovation will require additional policy changes, such as boosting R&D funding – U.S. R&D funding has fallen behind other industrialized nations as a percentage of GDP. See Robert D. Atkinson & Kevin Gawora, U.S. University R&D Funding Falls Further Behind OECD Peers, Information Technology & Innovation Foundation (2021). Fixing the cracks in America's innovation ecosystem will also require strengthening the R&D tax credit. See Tech Policy To-Do List, Information Technology & Innovation Foundation at 4 (2020).

[46] Remarks on Executing a Modern American Industrial Strategy by NEC Director Brian Deese, The White House (2022).

(IRA), which – if implemented quickly and effectively – will boost America's microelectronics and energy storage ecosystems.[47] A TIS should take these investments even further, upgrading America's techno-industrial base by rebuilding U.S. manufacturing, accelerating digital infrastructure, investing in the American workforce, unleashing innovation in the financial sector, and pushing back against China's distortionary industrial policies. Coordinating these efforts with U.S. allies and partners will enable synchronization of resources and policies, strengthening democratic advantage in the global competition with the PRC. [48]

The United States has a long history of employing industrial strategies to boost national advantage.[49] In 1791, Secretary of the Treasury Alexander Hamilton outlined a slate of measures to support American manufacturing in strategic industries.[50] Hamilton's vision was realized a few decades later under the American System, an industrial strategy that included subsidies to build railroads, canals, armories, and other forms of infrastructure.[51] Abraham Lincoln advanced this strategy by signing legislation that chartered the Transcontinental Railroad and established a system of land grant colleges.[52] By the 20th century, the United States emerged as a global power. Industrial strategy projects – including mobilizing the nation for World War II and the Apollo Program – strengthened the country's techno-economic foundation, readying it for the strategic rivalry with the Soviet Union.[53]

Today, the United States remains a global leader in technological innovation, but lags behind competitors in scaling breakthroughs and moving them into production.[54] From the 1950s through 1980s, America's technological engine was powered by large, vertically-integrated corporations that conducted extensive amounts of research and development (R&D), underwritten by federal R&D dollars.[55] Large companies had strong incentives to invest in early-stage research and move new technologies from the lab to mass production. But the breakup of this ecosystem by the 1990s, coupled with the distortionary impact of PRC industrial policies and incentives to reduce

[47] See Pub. L. 117-167, The CHIPS and Science Act of 2022 (2022); Pub. L. 117-169, Inflation Reduction Act of 2022 (2022).
[48] As National Economic Council Director Brian Deese has noted, "Enhanced engagement with our partners abroad is a matter of economic and geographic necessity. It's neither feasible nor advisable for us to produce everything domestically. We need international coalitions of reliable partners that reinforce secure supply chains and amplify our own sources of strength." See Remarks on Executing a Modern American Industrial Strategy by NEC Director Brian Deese, The White House (2022).
[49] See e.g., Stephen S. Cohen & J. Bradford DeLong, A Note on "Industrial Policy", &, Brad DeLong's Grasping Reality (2022).
[50] Alexander Hamilton, Final Version of the Report on the Subject of Manufactures, U.S. Department of the Treasury (1791).
[51] Maurice Baxter, Henry Clay and the American System, University Press of Kentucky at 49-54 (1995).
[52] Michael Lind, Land of Promise: An Economic History of the United States, Harper at 152-153 (2012); Land-Grant College Act of 1862, Encyclopedia Britannica (last accessed 2022).
[53] Arthur Herman, Freedom's Forge: How American Business Produced Victory in World War II, Random House at 192-200 (2012); Charles A. Murray & Catherine Bly Cox, Apollo: The Race to the Moon, Simon & Schuster at 25 (1989).
[54] See e.g., Jonas Nahm, Reimagine: Clean Energy Technology and U.S. Industrial Policy, Center for a New American Security at 9-10 (2022); Ashish Arora, et al., The Changing Structure of American Innovation: Some Cautionary Remarks for Economic Growth, Innovation Policy and the Economy (2020); GAO-21-202, DEPARTMENT OF ENERGY: Improved Performance Planning Could Strengthen Technology Transfer, U.S. Government Accountability Office at 2 (2021).
[55] Ashish Arora, et al., Why the U.S. Innovation Ecosystem Is Slowing Down, Harvard Business Review (2019).

labor and capital expense, drove a wedge into America's technological model.[56] As a result, the United States no longer has the infrastructure and workforce in place to scale technological breakthroughs, while sheer complexity, stifling regulation, short-term capital markets, and high fixed capital expenditures have channeled financial capital away from deep tech toward software.[57] Scientists in the United States drove basic research for technologies like lithium-ion batteries, drones, solar panels, and microelectronics, but these technologies are now manufactured at scale in East Asia, leaving the United States dependent on imports.[58]

To address these issues, an American techno-industrial strategy should begin by boosting the diffusion of emerging technologies across the economy. This means shoring up systemic factors – including technical talent, digital infrastructure, intellectual property (IP) frameworks, and regulatory environments – that support and shape the innovation ecosystem. Ultimately, an industrial strategy with a focus on technology can yield spillover benefits for the entire economy and ordinary Americans.[59] As new technologies move into the market, adoption allows workers to complete tasks more efficiently, increasing productivity. Economic and historical evidence suggest that the development and diffusion of technology is the chief factor in improved productivity and, consequently, higher rates of economic growth.[60] To take one example, Cold War R&D funding for the Defense Advanced Research Projects Agency (DARPA) – whose mandate focuses on technologies relevant to defense – led directly to the development of ARPANet, an early predecessor to the Internet. As this technology diffused across the economy over the following decades, it has unleashed trillions of dollars in economic growth.[61]

A techno-industrial strategy should also prioritize filling economic and national security gaps. For example, the hollowing out of America's industrial base has created dependencies and left the United States vulnerable to supply shocks.[62] In addition, Beijing has benefited from massive flows

[56] Ashish Arora, et al., Why the U.S. Innovation Ecosystem Is Slowing Down, Harvard Business Review (2019); Willy C. Shih, Bringing Manufacturing Back to the U.S. Is Easier Said Than Done, Harvard Business Review (2020); Suzanne Berger, How Finance Gutted Manufacturing, Boston Review (2014); David Autor, et al., The China Shock and Its Enduring Effects, Stanford Center on China's Economy & Institutions (2022).
[57] Antoine Gourévitch, et al., Deep Tech and the Great Wave of Innovation, Boston Consulting Group (2021); Josh Lerner & Ramana Nanda, Venture Capital's Role in Financing Innovation: What We Know and How Much We Still Need to Learn, Journal of Economic Perspectives at 245-248 (2020). Due to regulatory hurdles, the United States builds manufacturing facilities for microelectronics and other strategic industries slower than other industrialized nations. See John VerWey, No Permits, No Fabs: The Importance of Regulatory Reform for Semiconductor Manufacturing, Center for Security and Emerging Technology at 5-10 (2021).
[58] Jonas Nahm, Reimagine: Clean Energy Technology and U.S. Industrial Policy, Center for a New American Security at 9-12 (2022); 2021 State of the U.S. Semiconductor Industry, Semiconductor Industry Association at 10-19 (2021); Cate Cadell, Drone Company DJI Obscured Ties to Chinese State Funding, Documents Show, Washington Post (2022).
[59] Gregory Tassey, The Economic Rationales and Impacts of Technology-Based Economic Development Policies, Economic Policy Research Center at 1-5 (2018); Marc Fasteau & Ian Fletcher, The Economic Foundations of Industrial Policy, Palladium (2020).
[60] As Gregory Tassey notes, "advances in technology are the only source of permanent increases in productivity." See Gregory Tassey, Beyond the Business Cycle: The Need for a Technology-Based Growth Strategy, National Institute of Standards and Technology at 2 (2012). See also Richard G. Lipsey, et al., Economic Transformations: General Purpose Technologies and Long-Term Economic Growth, Oxford University Press at 85-218 (2005).
[61] William B. Bonvillian, et al., The DARPA Model for Transformative Technologies: Perspectives on the U.S. Defense Advanced Research Projects Agency, OpenBook Publishers at 145-176 (2019).
[62] Janet Yellen, Economic Growth Is Essential. So Is Resilience, The Atlantic (2022); E.O. 14017, Executive Order on

of U.S. capital, technology, and information and leverages distortionary industrial policy to undercut American industry. Finally, the United States, with its allies and partners, must ensure it remains ahead of Beijing's efforts to leverage novel financial technologies and international payment rails to undermine U.S. leadership in global finance.

Realizing the promise of emerging technologies will require the United States to get organized. America has entered a sustained, long-term rivalry in which technological leadership, control over technology chokepoints, and the ability to generate wealth for citizens will have strategic effect. But changing the status quo requires significant changes to how the government does business. The United States must draw on its legacy of successful public-private partnerships to build a techno-industrial strategy that plays to America's strengths. Then, the United States can leverage and reinforce its economic advantages, including its world-leading innovation ecosystem, deep capital markets, world-class workforce, and close ties with other democracies. For a TIS to succeed, policymakers must:

1. *Organize to Inform and Execute.* To create and implement a techno-industrial strategy, the United States needs new policy and intelligence functions responsible for convening government and industry experts and ensuring they have the information they need. America needs the creation of a new model for technology advantage to coordinate between public and private stakeholders, provide analytical capacity to inform policymakers, and implement action plans to push strategic technologies forward.[63] To support this process, the United States should boost analytic capacity, including at the Department of Commerce and create a National Techno-Economic Intelligence Center to capture, master, and disseminate economic, financial, and technological intelligence.[64]

2. *Prioritize Competition.* Successful industrial strategies encourage – not stifle – competition among firms.[65] Within an industrial policy framework, the government can provide demand when markets fall short and harness private-sector competition to meet national needs.[66]

3. *Encourage Risk-Taking.* Implementing a techno-industrial strategy will require the U.S. Government to shoulder additional risk. This will require America to "experiment with new ways of incentivizing technology development, even if some efforts result in wasted funds or fail entirely."[67]

America's Supply Chains: A Year of Action and Progress, The White House at 6-8, 18-28 (2022); Nadia Schadlow, Trading One Dependency for Another, War on the Rocks (2021); Emily de La Bruyère & Nathan Picarsic, Elemental Strategy, Foundation for the Defense of Democracies (2022).

[63] Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 53-54 (2022).

[64] SCSP has recommended the creation of a National Techno-Economic Intelligence Center that can warn of foreign threats to the U.S. economy, make sense of rivals' techno-economic strategies, and evaluate U.S. economic leverage. For more on this center and where it might be housed, see Intelligence in an Age of Data-Driven Competition, Special Competitive Studies Project at 28-34 (2022).

[65] State of Competition within the Defense Industrial Base, U.S. Department of Defense at 1-3 (2022).

[66] Philippe Aghion, et al., Industrial Policy and Competition, American Economic Journal: Macroeconomics (2015).

[67] Matt Sheehan, The Chinese Way of Innovation: What Washington Can Learn from Beijing About Investing in Tech, Foreign Affairs (2022).

4. *Provide Sources of 'Patient Capital' to Reshore Supply Chains and Help Technologies Scale.* To provide companies long-term support to commercialize and scale strategic technologies, the United States should pool public and private capital via a 'fund of funds' model, leveraging government support to de-risk private investment.[68] The United States also needs a standing funding mechanism that provides patient capital to scale manufacturing in critical sectors. One such proposal advocates the creation of an Industrial Finance Corporation (IFC), an independent development bank responsible for investing in the expansion, strengthening, and sustainment of America's domestic industrial base.[69]

5. *Insulate U.S. and Allied Markets from PRC Distortions:* To provide U.S. firms and firms from friendly nations a market environment free from Beijing's distortionary industrial policies and large enough to be profitable, the United States should restrict PRC firms' access to its markets in strategic sectors, doing so with allies and partners whenever possible to maximize combined market size.

Moving from Strategy to Action: A National Model for Technology Advantage

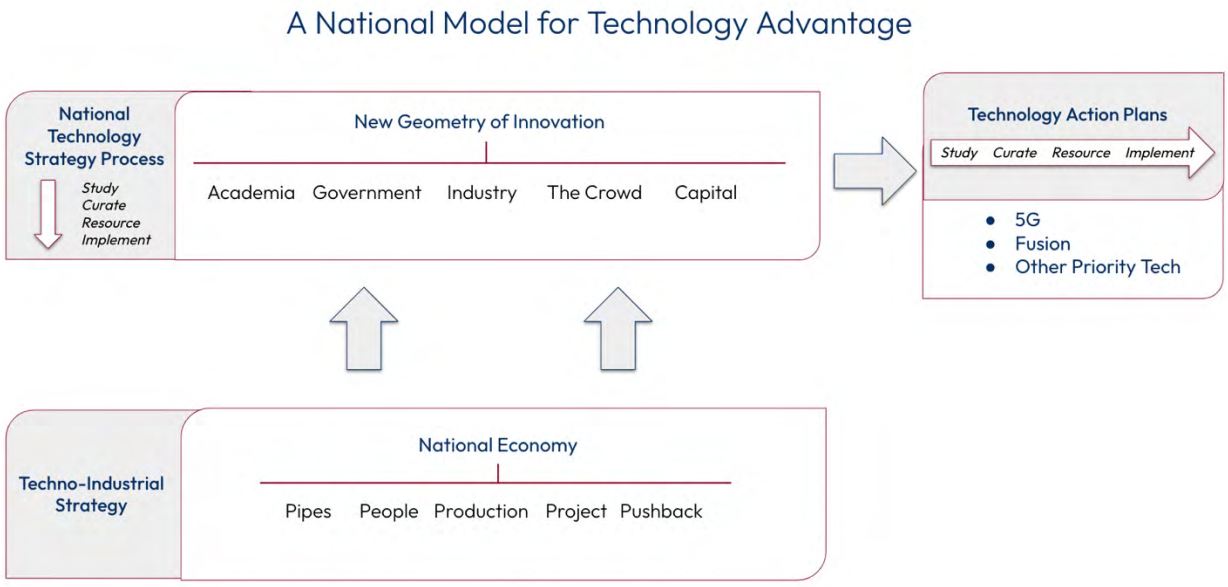
In addition to developing a techno-industrial strategy, the United States should create a process to operationalize it. This process should bring in constituencies that form the "new geometry of innovation"[70] – academia, government, industry, the web-enabled crowd, and venture capital – to develop national action plans. The action plans would be based on two levels of analysis. On the tech level, experts from around the country should routinely and systematically help shape bold technology objectives required to keep the United States ahead. On the policy level, the U.S. Government should incorporate economic, policy, and – if necessary – legislative moves to achieve national advantage. This policy level of planning should include industrial strategy variables as required, drawing from the five pillars of the TIS: production, pipes, people, project,

[68] As the U.S. National Economic Council Director Brian Deese has explained, an industrial strategy should leverage "public investment to crowd in more private investment." Remarks on Executing a Modern American Industrial Strategy by NEC Director Brian Deese, The White House (2022).

[69] Proponents of an IFC suggest structuring the entity loosely along the lines of the U.S. International Development Finance Corporation (DFC). See Jonas Nahm, Reimagine: Clean Energy Technology and U.S. Industrial Policy, Center for a New American Security at 14-16 (2022); Industrial Finance Corporation Act of 2021 – Summary, Office of Senator Chris Coons (2021).

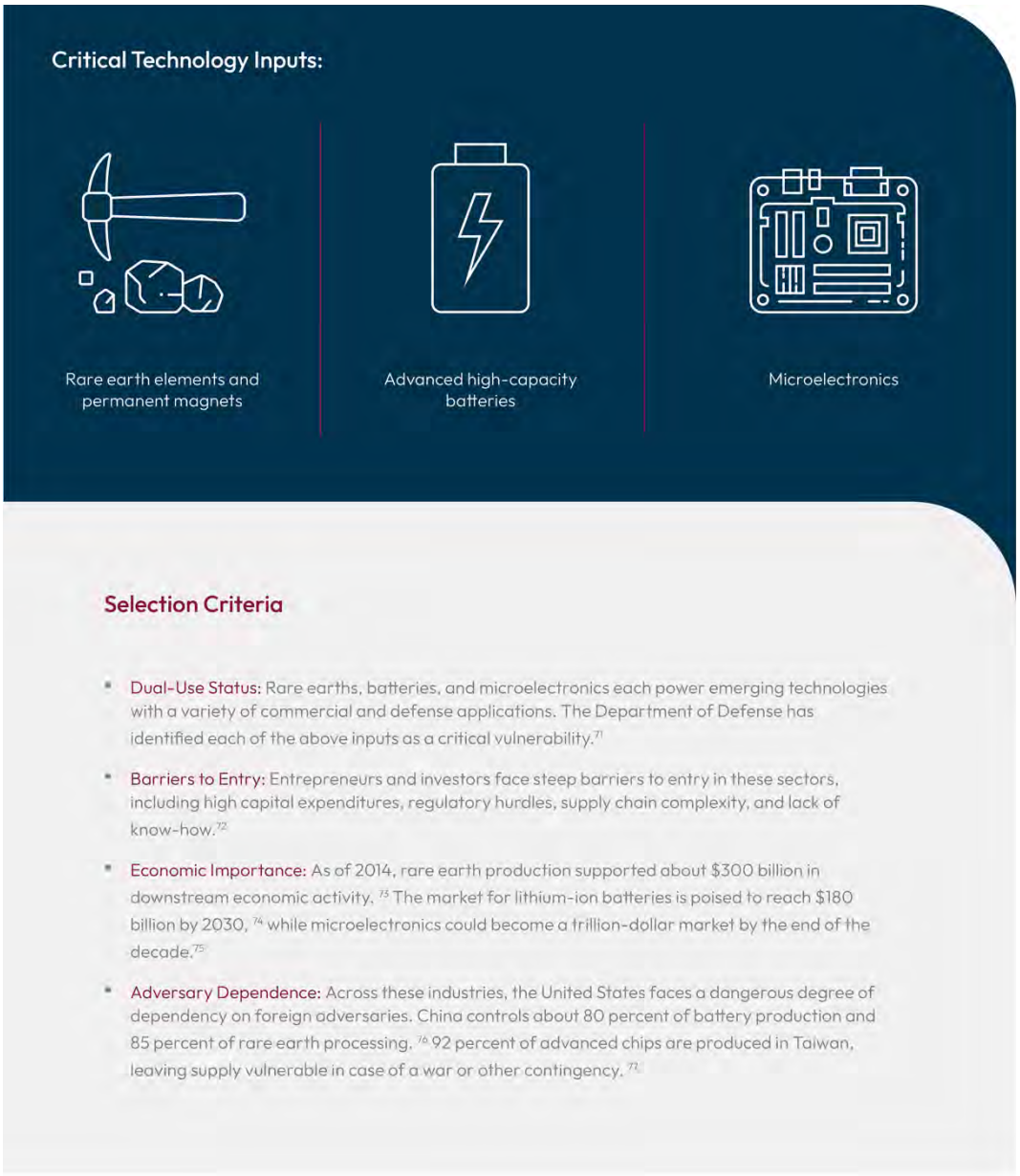
[70] To coordinate the efforts across stakeholders in the technology competition, in 2022, Congress considered legislation for both a Technology Competitiveness Council (TCC) and Office of Global Competition Analysis (OCA). H.R. 8027, To Establish Within the Executive Office of the President a Technology Competitiveness Council (2022); Courtney Albon, Lawmakers Propose 'Technology Competitiveness Council' to Champion US Innovation, C4ISRNet (2022); S. 4368, American Technology Leadership Act of 2022 (2022); Daniel Flatley, Senators Wary of China's Tech Prowess Seek Competition Office, Bloomberg (2022). The National Security Commission on Artificial Intelligence (NSCAI) recommended creating a TCC in its final report in 2021. Final Report, National Security Commission on Artificial Intelligence at 166 (2021). A combination of a TCC and an OCA could be a powerful duo in advancing U.S. organizational capacity to compete. OCA – housed in the Executive Office of the President, an executive agency, or a Federally Funded Research and Development Center – could provide analytical capacity for senior policymakers while remaining insulated from momentary political pressures and ensuring intellectual memory across administrations. A complementary TCC located in the White House would offer both a key point of engagement between governmental leaders and the private sector and an action arm for pursuing action plans and moving the national innovation ecosystem; Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 42-43 (2022).

and pushback. For an example of an action plan, see Appendix B of this report.



Chapter I: Production

From coal, steel, and rubber during the Industrial Age to rare earth elements today, the ability to produce and access critical technology inputs has long been a decisive factor in strategic competition. Modern technology platforms across the defense, energy, and communications industries rely on a variety of critical minerals and strategic inputs to power technology platforms and move data from place to place. Beijing has moved to cement its position across key nodes in strategic supply chains in an effort to create dependencies that provide geopolitical leverage. The United States must move swiftly to onshore and friendshore production capacity to ensure access to dual-use inputs in key sectors. Although hundreds of vulnerabilities exist across a variety of sectors, special focus should be placed on supply chains for *rare earth elements and permanent magnets, advanced high-capacity batteries, and microelectronics.*



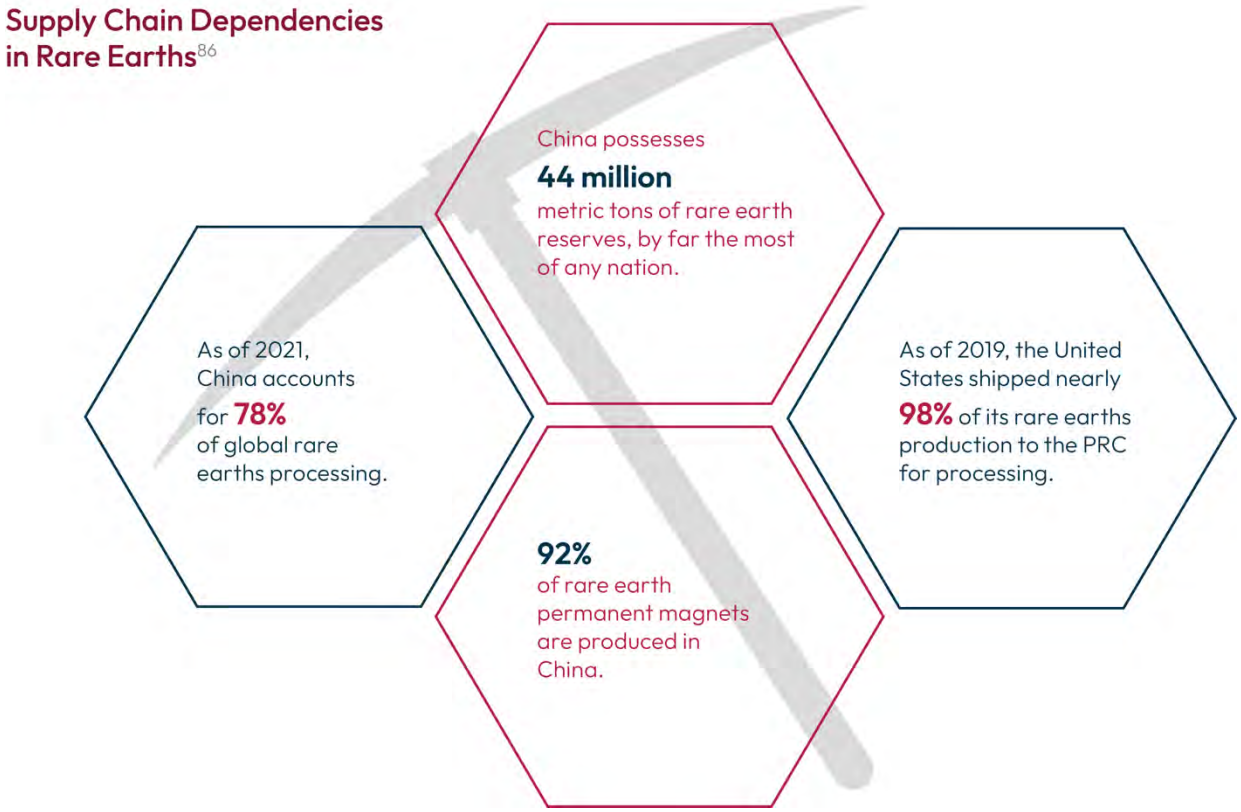
[71] Securing Defense-Critical Supply Chains: An Action Plan Developed in Response to President Biden's Executive Order 14017, U.S. Department of Defense (2022).
[72] Chris Power, et al., Rockets, Jets, and Chips: How to Modernize U.S. Manufacturing, Future (2022); John VerWey, No Permits, No Fabs: The Importance of Regulatory Reform for Semiconductor Manufacturing, Center for Strategic and Emerging Technologies (2021); Yifei Huang, Software Is the Tech You Date, But Hardware Is the Tech You Marry, London Business School Private Equity & Venture Capital Blog (2022).
[73] Ann Norman, et al., Critical Minerals: Rare Earths and the U.S. Economy, National Center for Policy Analysis at 3 (2014).
[74] Lithium-Ion Battery Market Size Worth $182.53 Billion By 2030: Grand View Research, Inc., Bloomberg (2022).
[75] Ondrej Burkacky, et al., The Semiconductor Decade: A Trillion-Dollar Industry, McKinsey & Company (2022).
[76] U.S. Narrows Gap with China in Race to Dominate Battery Value Chain, Bloomberg NEF (2022); Keith Zhai, China Set to Create New State-Owned Rare-Earths Giant, Wall Street Journal (2021).
[77] Antonio Varas, et al., Strengthening the Global Semiconductor Value Chain in an Uncertain Era, Boston Consulting Group and Semiconductor Industry Association at 5 (2021).

Rare Earth Elements & Magnets

Rare earths are a group of 17 elements found in a wide variety of technology products, from smartphones to defense systems to green technology.[78] A single iPhone contains eight different rare earth elements.[79] As of 2021, the PRC accounted for 78 percent of global production of these elements and an even higher percentage of processing.[80] The United States faces an acute vulnerability in rare earth magnets, which are used in weapons systems, wind turbines, and electric vehicle engines. Ninety-two percent are produced in the China.[81] The PRC has threatened to cut off U.S. rare earth supply several times, including as recently as 2021.[82]

U.S. administrations have begun to address this vulnerability. A single American source, Mountain Pass Mine in California, resumed production in 2018 and has helped boost production dramatically.[83] The Biden administration also is working to get additional mines online, with bipartisan congressional support.[84] The most serious bottleneck, however, still lies in the processing of rare earths. As of 2019, the United States shipped nearly 98 percent of its rare earths production to the PRC to be processed.[85]

[78] Rare Earths Statistics and Information, U.S. Geological Survey (2022).
[79] Edward Humes, Your iPhone's 500,000-Mile Journey to Your Pocket, Wired (2016).
[80] Mineral Commodities Summaries 2022: Rare-Earths, U.S. Geological Survey (2022); Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth, The White House at 9 (2021).
[81] Rare Earth Permanent Magnets: Supply Chain Deep Dive Assessment, U.S. Department of Energy at 25 (2022).
[82] See Sun Yu & Demetri Sevastopulo, The PRC Targets Rare Earth Export Curbs to Hobble US Defence Industry, Financial Times (2021); Keith Johnson & Elias Groll, The PRC Raises Threat of Rare-Earths Cutoff to U.S., Foreign Policy (2019). As a PRC government-funded project noted in 2019, "the PRC will not rule out using rare earth exports as leverage to deal with the [Trade War] situation." See Emily de La Bruyère & Nathan Picarsic, Absolute Competitive Advantage: Rare Earth Elements in the PRC's Strategic Planning, Horizon Advisory at 1 (2020).
[83] Mineral Commodity Summaries – Rare Earths, U.S. Geological Survey (2022). A PRC company also holds an eight percent stake in the project at Mountain Pass. See Mary Hui, A Chinese Rare Earths Giant is Building International Alliances Worldwide, Quartz (2021).
[84] FACT SHEET: Securing a Made in America Supply Chain for Critical Minerals, The White House (2022); S.3530, REEShore Act of 2022 (2022).
[85] Rare Earth Elements Supply Chains, Part 1: An Update on Global Production and Trade, U.S. International Trade Commission (2020). Earlier this year, the Department of Defense announced funding for Australian rare earths giant Lynas to build a rare earths processing facility in Texas through the Defense Production Act, but much more work remains to be done to meet U.S. civilian and defense needs. James Fernyhough, Pentagon Bankrolls Rare Earths Plant as US Plays Catch-Up to China, Financial Times (2022).



Key Actions:

- *In the short-term, America must accelerate stockpiling efforts to ensure sufficient supply of rare earths and other critical minerals in the event of a conflict.* Stockpiling can buy time for the United States in the event of a war, national emergency, or other disruption. Prior to World War II, President Franklin D. Roosevelt ordered the U.S. Government to stockpile natural rubber supplies, an effort that bought 18 months for American industry to develop and scale up synthetic rubber production for this defense-critical industry.[87] The United States needs a similar effort today.[88] Stockpiling efforts for rare earths are currently underway, but they should be expanded to meet demand.[89] The Department of Defense should be granted additional funding to accelerate stockpiling efforts and guarantee supply of rare earth oxides and magnets for major defense acquisition programs.[90]

[86] Kelsi Van Veen and Alex Melton, Rare Earth Elements Supply Chains, Part 1: An Update on Global Production and Trade, U.S. International Trade Commission (2020); Does China Pose a Threat to Global Rare Earth Supply Chains?, China Power, Center for Strategic and International Studies (2021).
[87] U.S. Synthetic Rubber Program, American Chemical Society (last accessed 2022).
[88] U.S. Departments of Energy, State and Defense to Launch Effort to Enhance National Defense Stockpile with Critical Minerals for Clean Energy Technologies, U.S. Department of Energy (2022).
[89] The National Defense Stockpile currently sits at about 2 percent of its Cold War value. See Bryant Harris, Congress Wants to Double Rare Earth Mineral Fund to Free Defense Supply Chain from China, DefenseNews (2022).
[90] See Emily de La Bruyère & Nathan Picarsic, Elemental Strategy: Countering the Chinese Communist Party's Efforts to Dominate the Rare Earth Industry, Foundation for the Defense of Democracies (2022). Under Title III of the

Stockpiling initiatives also serve to de-risk investment, providing a guaranteed source of demand for new mining and magnet production.

- *To meet demand for clean energy generation and storage while reducing dependence on the PRC, the United States should channel public and private investment toward friendshoring, while providing incentives for domestic production.* Earlier this year, the State Department announced the Minerals Security Partnership – an investment vehicle to pool funds from partner governments to invest in clean mining and processing.[91] This program should be rapidly scaled and reliably funded, and efforts should be launched to attract private sector investment. In addition, Washington should provide funding and strategic direction to the U.S. International Development Finance Corporation and other U.S. financing agencies, as well as leveraging the Defense Production Act, to direct additional investments in mining and processing facilities in partner countries.[92] In addition, the United States should offer tax credits and other incentives to boost domestic mineral processing (see below).

- *Begin curbing imports of critical minerals mined and processed by PRC companies.* Beyond issues of supply chain resilience and strategic dependence, PRC mining companies have a long history of committing human rights violations, both within the PRC and around the world, as well as leaving a significant environmental footprint.[93] Significant steps are needed to ensure that PRC mineral producers do not enjoy a stranglehold over the U.S. market. As a starting point, policymakers should take steps to restrict the use of rare earth minerals mined and processed by PRC companies for U.S. defense platforms.[94] Combined, stockpiling and curbing imports would generate a tremendous demand signal to rebuild domestic production.

- *In the medium- and long-term, the United States should explore alternative, sustainable production methods, including recycling, deep-sea mining, and space mining.* A fraction of rare earths are currently recycled, but new processing methods and recycling regulations could help to meet demand sustainably.[95] Alternative sourcing methods are needed to offset the PRC's dominance in critical mineral processing. The Department of Energy is currently testing the viability of extracting rare earths from coal tailings, for

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Defense Production Act, the President has determined that there is a shortfall in the defense industrial base in this sector, making funding available for loans, loan guarantees, and grants. See Steve Mufson & Paulina Villegas, Biden to Use Defense Production Act for U.S. Critical-Minerals Supply, Washington Post (2022).

[91] Minerals Security Partnership, U.S. Department of State (2022).

[92] See e.g., Ernest Scheyder, Pentagon Asks Congress to Fund Mining Projects in Australia, U.K., Reuters (2022).

[93] Human Rights Claims Undermine China's Investment Abroad, Report Finds, Reuters (2021); William Laurance, The Dark Legacy of China's Drive for Global Resources, Yale Environment 360 (2017).

[94] The U.S. Government has started to make progress in this direction; additional action to secure U.S. access to critical minerals is required. See, for example, Ernest Scheyder, EXCLUSIVE U.S. Bill Would Block Defense Contractors from Using Chinese Rare Earths, Reuters (2022); S.3530, REEShore Act of 2022 (2022); Emily de La Bruyère & Nathan Picarsic, Elemental Strategy: Countering the Chinese Communist Party's Efforts to Dominate the Rare Earth Industry, Foundation for the Defense of Democracies (2022).

[95] Diana Kinch, Recycling Could Account for 25% of Rare Earths Market in 10 Years: Mkango CEO, S&P Global (2021).

instance.[96] Deep-sea deposits off America's Pacific coast are rich in rare earths and other critical minerals necessary for high-capacity batteries. Space mining also offers a potential avenue to mine critical minerals in the long-term.[97] In addition, U.S.-based research teams have developed methods to produce rare earth magnets via additive manufacturing.[98] Exploring new sources of rare earths and other critical minerals will require policy frameworks that balance environmental concerns with the competitiveness of U.S. and allied nation firms.[99]

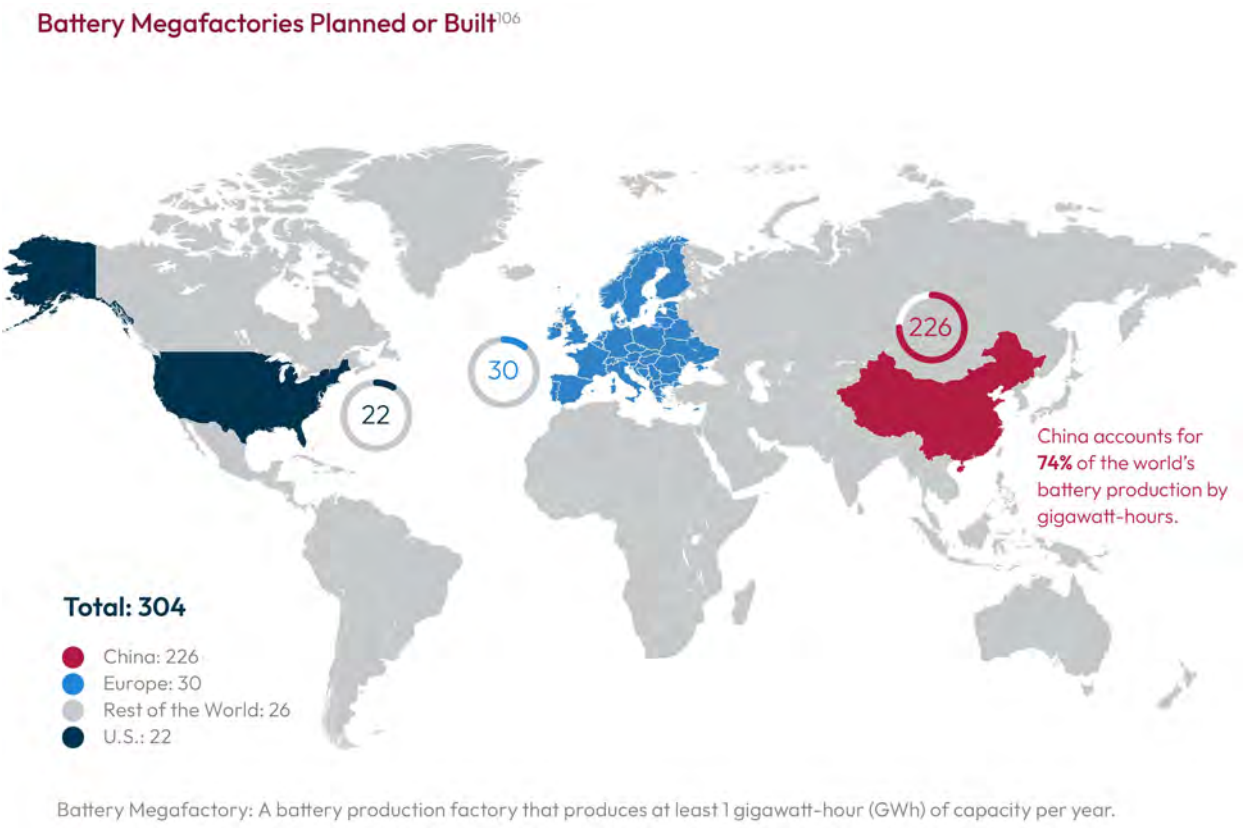
Advanced High-Capacity Batteries

The world has entered a transition from an energy supply reliant chiefly on fossil fuels to a diversified supply featuring renewable forms of energy as countries seek to mitigate the effects of carbon-induced climate change. Advanced high-capacity batteries will be key to this effort. Batteries are used to store renewable energy, power electric vehicles, and supply energy to the battlefield. Last year, the White House set an ambitious target for 50 percent of all new domestic car sales to be electric by 2030.[100] But the Department of Energy estimates that the United States only has about five percent of the battery production capacity it needs to reach this target.[101]

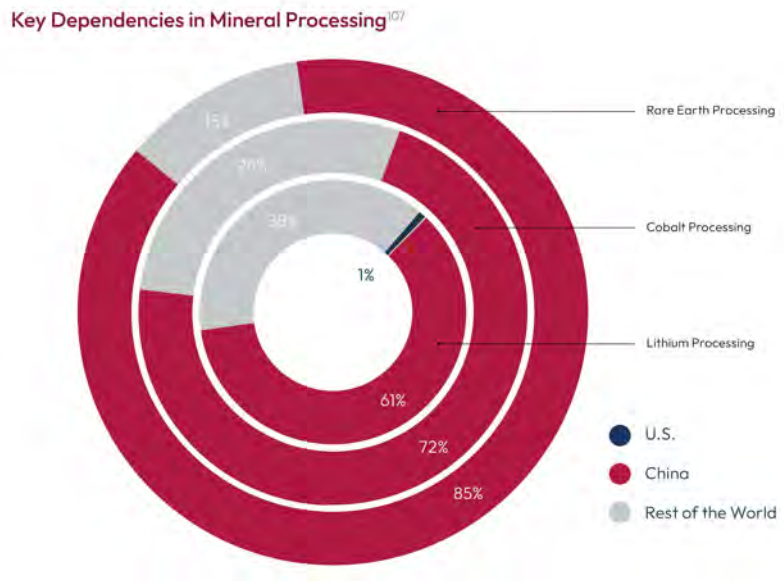
Today, PRC companies dominate almost every step of the supply chain for advanced batteries. Battery experts estimate that the United States has fallen about 10 years behind the PRC.[102] China accounts for almost 80 percent of global battery production and is unlikely to relinquish its lead anytime soon.[103] Of a global total of 304 battery megafactories in various stages of operation, construction or planning, 226 are or will be located in China.[104] The PRC also dominates the upstream supply chain. Battery manufacturing requires several types of critical minerals, including lithium, cobalt, nickel, and graphite, that must be mined and processed before they are packed into battery cells. The PRC has spent years establishing control over supply chains for

[96] DOE Launches $140 Million Program to Develop America's First-of-a-Kind Critical Minerals Refinery, U.S. Department of Energy (2022); Luver Echeverry-Vargas & Luz Marina Ocampo-Carmona, Recovery of Rare Earth Elements from Mining Tailings: A Case Study for Generating Wealth from Waste, MDPI (2022).
[97] In 2020, NASA announced contracts with companies to extract rock and debris on the Moon, "effectively beginning the era of commercial space mining." Alex Gilbert, Mining in Space Is Coming, Milken Institute Review (2021); see also Mike Wall, Asteroid-Mining Startup AstroForge Raises $13 Million, Books Launch for Test Mission, Space.com (2022).
[98] H. Wang, et al., Review of Additive Manufacturing of Permanent Magnets for Electrical Machines: A Prospective on Wind Turbine, Materials Today Physics (2022).
[99] Elizabeth Kolbert, Mining the Bottom of the Sea, The New Yorker (2021). For example, the United States has not ratified the United Nations Convention on the Law of the Sea (UNCLOS), which attempts to restrict deep-sea mining, but UNCLOS supporters believe that U.S. firms must abide by the regime, creating uncertainty for companies and investors. The U.S. Government should issue clearer guidance on how industry players should proceed. See Dennis Blair, The Undersea Trove for Electric Vehicles, Wall Street Journal (2022).
[100] FACT SHEET: President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks, The White House (2021).
[101] Ernest Scheyder, Syrah Resources Gets $107 Mln U.S. Loan for Louisiana EV Battery Plant, Reuters (2022).
[102] The Challenge of Building a Lithium Battery Supply Chain in North America, NAATBatt International (2021).
[103] U.S. Narrows Gap With China in Race to Dominate Battery Value Chain, Bloomberg NEF (2021).
[104] Global Gigafactory Pipeline Hits 300; the PRC Dominates but the West Gathers Pace, Benchmark Mineral Intelligence (2022).

these minerals and now controls 100 percent of graphite processing, about 72 percent of cobalt processing, and 61 percent of lithium processing.[105]



[105] America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition, U.S. Department of Energy at 13 (2022).
[106] Global Gigafactory Pipeline Hits 300; China Maintains Lead but West Gathers Pace, Benchmark Mineral Intelligence (2022).
[107] America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition, U.S. Department of Energy (2022).



Simply put, deepening U.S. energy dependence on America's strategic rival grants Beijing leverage and is unacceptable. PRC producers of critical minerals and battery cell components have also been linked to human rights abuses in Xinjiang.[108] Congress and the Biden administration have taken significant steps to address U.S. dependence:[109] the IRA, passed earlier this year, represents the largest U.S. Government investment in clean energy supply chains and advanced batteries to date.[110] The legislation jump-starts efforts to build a North American battery supply chain, driving localization by incentivizing battery cell production and electric vehicle assembly in North America through changes to the 30D clean vehicle tax credit. These credits also promote onshoring and friendshoring of critical mineral producing and processing, thanks to requirements that critical minerals be produced and processed either in the United States or in nations with which Washington has a free trade agreement (FTA).[111] Given the scale of the challenge, however, building a resilient and secure battery supply chain will require additional resources and policy actions.

The United States should take a three-pronged approach that combines existing efforts with new policies and moonshots to offset PRC dominance in lithium-ion batteries. First, the United States should accelerate efforts to build a regionalized supply chain for battery assembly and production of battery cells and key components, while focusing friendshoring efforts upstream on mining and processing. Second, policymakers should accelerate efforts to develop alternative

[108] Ana Swanson & Chris Buckley, Red Flags for Forced Labor Found in China's Car Battery Supply Chain, New York Times (2022).
[109] FACT SHEET: Biden-Harris Administration Driving U.S. Battery Manufacturing and Good-Paying Jobs, The White House (2022); Executive Summary: National Blueprint for Lithium Batteries, 2021-2030, Federal Consortium for Advanced Batteries (2021).
[110] Inflation Reduction Act of 2022, U.S. Department of Energy (last accessed 2022).
[111] Pub. L. 117-169, Inflation Reduction Act of 2022 (2022).

battery chemistries,[112] and their respective ecosystems, to offset PRC investments in aging lithium-ion technology. Third, policymakers should build on guardrails in the IRA by leveraging a combination of inbound and outbound investment restrictions, local content requirements, and trade tools to prevent PRC battery giants from further penetrating American markets.

Key Actions:

Build a Resilient, Regionalized Battery Ecosystem

- *Focus onshoring efforts on production capacity for key components that make up battery cells.* China dominates production for lithium-based cathodes (81 percent) and graphite-based anodes (91 percent), which are used to manufacture battery cells. The United States accounts for less than half a percent of global cathode and anode production.[113] Given that the battery industry is especially prone to agglomeration, leveraging IRA and Infrastructure Investment and Jobs Act funding to build additional facilities in North America would exert a gravitational pull on the supply chain, creating a demand signal strong enough to attract additional upstream and downstream suppliers. Earlier this year, for example, the Department of Energy's Loan Programs Office provided support to build the world's first non-PRC source of graphite anode material in Louisiana.[114]

- *Focus friendshoring efforts further upstream in the supply chain.* Lithium-ion batteries are difficult and costly to transport, meaning that cathode and anode production, battery cell production, and battery assembly are often best done regionally. The United States should work with its allies and partners to bring as many mines and processing facilities for critical minerals like lithium, graphite, nickel, and copper online as possible. Key opportunities exist to strengthen cooperation with and promote investment in countries in Latin America. The Partnership for Global Infrastructure Investment (PGII) launched by President Biden and G7 leaders at the 2021 G7 Summit should also be used to facilitate investments in clean mining and processing, as well as production for battery cell components.[115] Current friendshoring programs are promising but have yet to yield sufficient results at scale.

- *Rapidly proceed with proposed permitting reforms.* Recent estimates suggest that meeting demand for electric vehicles will require an additional 300 mines brought online within the next decade.[116] The United States holds vast mineral reserves, but slow permitting processes and a labyrinth of environmental laws and unconstrained private litigation actions mean opening new mines domestically tends to be unfeasible.[117] Since February 2022, a U.S. Government task force has studied ways to fast-track permitting

[112] Testimony of Spencer Nelson before the U.S. Senate Energy and Natural Resources Committee, Opportunities and Challenges for Deploying Innovating Battery and Non-Battery Technologies for Energy Storage (2022).
[113] What Does the US Inflation Reduction Act Mean for the EV Battery Supply Chain?, Benchmark Mineral Intelligence (2022).
[114] David Shepardson, U.S. Finalizes $102.1 Mln Loan to Syrah Resources for Louisiana Plant, Reuters (2022).
[115] FACT SHEET: President Biden and G7 Leaders Formally Launch the Partnership for Global Infrastructure and Investment, The White House (2022).
[116] More Than 300 New Mines Required to Meet Battery Demand by 2035, Benchmark Mineral Intelligence (2022).
[117] Ernest Scheyder & Valerie Volcovici, Push to Shorten U.S. Mine Permit Review Process Gains Steam, Reuters (2022); Dean Scott & Stephen Lee, Pitfalls Await Biden's Bid to Boost Mineral Mining for EVs (1), Bloomberg Law (2021).

processes for mines and production facilities.[118] Its recommendations should be seriously considered.

- *Launch training programs aimed at building America's battery engineering and mining workforce.* As domestic battery production ramps up, the United States could face significant workforce shortages.[119] These challenges will be especially acute in the mining industry, which has seen a 20 percent drop in employment over the past decade.[120] Federal investment is necessary to fill the gap. Policymakers should:
    - Incentivize universities to fund undergraduate, Master's, and PhD programs in battery engineering, sponsored by major automakers; and
    - Provide funding for community colleges and state universities to create programs in battery manufacturing, mineral processing, and mining, sponsored by industry partners. Digital technologies should be leveraged to scale technical training programs.[121]

Create a Parallel Ecosystem for Alternative Battery Chemistries

- *The United States needs a moonshot for batteries.* Several promising battery chemistries exist that minimize reliance on critical minerals produced and processed in China. Today, lithium-ion chemistries dominate applications from cell phones to electric vehicles, but lithium prices have ballooned by nearly 1000 percent since August 2020 and shortages may loom as early as 2025.[122] The United States needs a national effort to develop, resource, and scale next-generation chemistries for EV batteries, with a goal of exceeding the performance of lithium-ion technology while cutting reliance on critical minerals produced and processed in the PRC. By investing in next-generation battery technologies, such as sodium-ion and molten-salt chemistries, the United States has a narrow window of opportunity to offset China's dominance in aging lithium-ion technology and reduce dependence on the PRC.[123] A battery moonshot should:
    - Offer flexible terms of employment to leading battery scientists and industry experts from national labs, academia, start-ups, and oversea;
    - Have a 5- to 10-year time horizon;
    - Focus on chemistries that minimize the use of critical minerals with significant dependencies on China, but otherwise take a technology-neutral approach before narrowing down its portfolio; and
    - Leverage federal seed funding and secure backing from industry partners, which would agree to scale manufacturing operations and sign offtake agreements if benchmarks are met.

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[118] Interior Department Launches Interagency Working Group on Mining Reform, U.S. Department of the Interior (2022).
[119] Heekyong Yang, Battery Giants Face Skills Gap That Could Jam Electric Highway, Reuters (2021).
[120] Anthony Barich & Taylor Kuykendall, Miners' Labor Supply Problem Goes from 'Challenging' to 'Diabolical', S&P Global (2022).
[121] See e.g., UpSmith, UpSmith (last accessed 2022).
[122] Nathan Bomey, Lithium Prices Putting Pressure on Electric Vehicle Costs, Axios (2022); Ian Shine, The World Needs 2 Billion Electric Vehicles to Get to Net Zero. But Is There Enough Lithium to Make All the Batteries?, World Economic Forum (2022).
[123] Energy Report Part 1: Energy Storage, TechNext (2022) *(SCSP commissioned work product)*.

- *Roll out a comprehensive incentive program to promote the development and commercialization of alternative chemistries.* The Department of Energy should roll out a program featuring grants, loans, and tax credits, as well as commercialization support, specifically for startups developing next-generation chemistries for electric vehicle applications. Challenging the market dominance of lithium-ion batteries will require massive economies of scale. Ample government support is needed to de-risk private investment and sustain innovation in these chemistries.[124]

Curb PRC Market Access

- *Block PRC firms from building battery megafactories in North America.* China's national champion CATL is currently in talks to build a megafactory in Canada, Mexico, or the United States, which would deepen automakers' dependence on the PRC for clean energy.[125] Relying on foreign manufacturers is necessary in the absence of strong domestic players, but Washington should prevent PRC battery giants from expanding their footprint in the North American market. Foreign battery producers, especially U.S. allies and partners, that play by the rules and reduce their reliance on PRC-controlled supply chains should continue to be granted access to the U.S. market.

- *Reinforce guardrails in the Inflation Reduction Act to incentivize the creation of a PRC-free battery supply chain.* Current IRA guardrails discourage the import of raw materials from countries with which the United States does not have a free trade agreement – including Indonesia and Argentina, which rank among the world's largest producers of nickel and lithium, respectively.[126] The Department of Energy should expand IRA guardrails beyond free trade agreement (FTA) countries to permit the import of raw materials from additional U.S. allies and partners, provided source companies are not owned and operated by the PRC.

Microelectronics

Semiconductors are the brains of modern technology. These tiny chips provide the computing power necessary to develop AI models, perform missile calculations, and power smartphones. Microelectronics were first developed in the United States during the Cold War.[127] Over the past three decades, however, the United States has lost 70 percent of its chip manufacturing capacity, leaving it highly dependent on a handful of companies in East Asia.[128] About 98 percent of the semiconductors used by the Department of Defense (DoD) are produced, assembled, tested, or packaged in the region.[129] The PRC has also doubled down on funding microelectronics startups while U.S. venture funding for hardware has stagnated. In 2021, microelectronics startups in

[124] Reed Blakemore, et al., Alternative Battery Chemistries and Diversifying Clean Energy Supply Chains, Atlantic Council at 17 (2022).
[125] China's CATL Presses Ahead with Battery Plans for North America - Source, Reuters (2022).
[126] Pub. L. 117-169, Inflation Reduction Act of 2022, §13401 (2022); Mineral Commodities Summary 2022 – Nickel, U.S. Geological Survey (2022); Mineral Commodity Summary 2022 – Lithium, U.S. Geological Survey (2022).
[127] T.R. Reid, The Chip: How Two Americans Invented the Microchip and Launched a Revolution, Random House at 147-152 (2001).
[128] Stephen Ezell, Going, Going, Gone? To Stay Competitive in Biopharmaceuticals, America Must Learn from Its Semiconductor Mistakes, Information Technology & Innovation Foundation (2021).
[129] Deputy Secretary of Defense Dr. Kathleen Hicks' Remarks at the White House CHIPS-Plus Act Event (As Delivered), U.S. Department of Defense (2022).

China received six times the level of investment in comparable U.S. firms.[130] This funding gap is due in part to the cost and time required for chip startups to be successful. Hardware startups often require hundreds of millions of dollars and a decade of development to launch a successful product. Without lowering the costs and accelerating the pace of domestic semiconductor innovation, the United States risks falling behind in the race to determine leadership in the next generation of microelectronics.

To address this vulnerability, Congress passed the CHIPS and Science Act, a major legislative package that includes a $52 billion investment in America's semiconductor ecosystem, as well as the FABS tax credit. The legislation allocates $39 billion has been to build production capacity, with $11 billion allocated for microelectronics R&D.[131] But the work is not over – additional actions are needed to ensure the CHIPS Act is successfully implemented with maximum impact. Policymakers should:

- *Take risks and go for moonshots.* Taking an overly conservative, incremental approach to CHIPS implementation may patch immediate vulnerabilities, but it will not be enough to position the United States to lead the development of advanced compute technologies beyond 2030. To "ensure long-term leadership" in microelectronics, a stated goal of the program,[132] the nation must be willing to take calculated risks that harness its economic advantages, including the strength of U.S. capital markets, and leverage CHIPS funding to be greater than the sum of its parts. For example, the National Semiconductor Technology Center (NSTC) should fund the development of disruptive, breakthrough technologies in areas such as electronic design automation, lithography, materials, and packaging. DARPA's Electronics Resurgence Initiative offers a useful model for driving disruptive innovation that translates into results.[133]

- *Provide substantial funding to create the Semiconductor Industry Investment (Si²) Fund, an investment fund focused on leveraging private and public capital for maximum impact.* The Biden administration has marked "catalyz[ing] private-sector investment" as a key objective for CHIPS Act implementation.[134] Government funding for production capacity and innovation, properly implemented, could crowd more investment capital into the semiconductor manufacturing space, potentially increasing total investment by several multiples by de-risking private and institutional investment in the sector.[135] The Si² Fund would act as a fund of funds for the microelectronics sector, providing government funding to dedicated private sector or regional public-private funds that invest in the domestic semiconductor manufacturing ecosystem.[136]

[130] Coco Liu, China Venture Funding Hits Record $131 Billion Despite Crackdown, Bloomberg (2022).
[131] Pub. L. 117-167, The CHIPS and Science Act of 2022 (2022).
[132] E.O. 14080, Executive Order on the Implementation of the CHIPS Act of 2022, The White House (2022).
[133] DARPA Electronics Resurgence Initiative, Defense Advanced Research Programs Agency (2022).
[134] E.O. 14080, Executive Order on the Implementation of the CHIPS Act of 2022, The White House (2022).
[135] For example, In-Q-Tel estimates that, for every $1 in public funding invested, the fund leverages approximately $18 in private sector investment. See How We Work, In-Q-Tel (last accessed 2022).
[136] Establishing a Si² Fund would move final financial decisions to fund managers responsible to private equity partners with experience in investment decisions, deal structure, and risk premium discovery. It would also avoid "picking winners." Independent funds could leverage state pension funds (to draw matching funds from state and local governments), private firms, foundations, and private equity and hedge funds anchored by CHIPS funding. Federal,

- *Ensure that next-generation chips are designed and built in America by prioritizing prototyping and earmarking additional incentives for chip startups.* Last year, the PRC saw six times as many chip startups form as the United States.[137] To ensure the United States capitalizes on new breakthroughs, policymakers must work to lower costs and barriers to entry for semiconductor startups. Earmarking up to $1 billion for a full package of incentives – including grants, commercialization support, and tax credits – would help firms launch and scale, as would leveraging the National Semiconductor Technology Center and National Network for Microelectronics R&D programs included in the CHIPS Act to invest in the capabilities startups need to conduct prototyping.[138]

- *Address America's semiconductor talent gap.*[139] The United States faces a talent gap upwards of 90,000 microelectronics workers in the coming years.[140] The CHIPS Act can serve as a down payment to address it, though additional funding and immigration actions are needed.[141] Swift implementation of key CHIPS programs designed to help American engineers get hands-on experience with advanced equipment would accelerate the talent pipeline. Today, universities lack access to industry-standard equipment, often forcing companies to train new graduates for a year or more before they become productive employees.[142] Meeting demand will also require funding from industry and government for technical education, as many workers in manufacturing fields lack a college degree. Ultimately, however, building production capacity will also require the United States to fix skilled immigration pipelines. The United States should exempt STEM PhDs and Master's degree holders working in the chip industry from green card caps and grant additional employment-based visas to lure chip engineers.[143]

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state and local governments should also provide tax credits, support for licensing technologies, and grants to encourage domestic suppliers to expand production capacity for prototyping facilities, leading-edge nodes and defense-critical microelectronics.

[137] PCAST Releases Recommendations on Semiconductors R&D, The White House (2022); Dylan Patel, Why America Will Lose Semiconductors - Tangible Bi-Partisan Solutions for Solving a National Security Crisis, SemiAnalysis (2022).

[138] Pub. L. 116-283, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, § 9903-9906 (2021); CHIPS for America: A Strategy for the CHIPS for America Fund, U.S. National Institute of Standards and Technology (2022); Draft National Strategy on Microelectronics Research, U.S. Office of Science and Technology Policy at 6 (2022).

[139] Will Hunt, Reshoring Chipmaking Capacity Requires High-Skilled Foreign Talent: Estimating the Labor Demand Generated by CHIPS Act Incentives, Center for Strategic and Emerging Technologies (2022).

[140] Stephanie Yang, Chip Makers Contend for Talent as Industry Faces Labor Shortage, Wall Street Journal (2022); How the U.S. Can Reshore the Semiconductor Industry, Eightfold.AI at 5 (2022).

[141] The package includes $200 million in federal dollars for workforce development, but meeting demand may require up to $8 billion in total investment, according to Commerce Department estimates. See CHIPS for America: A Strategy for the CHIPS for America Fund, U.S. Department of Commerce, U.S. Department of Commerce at 12 (2022); Fueling American Innovation & Growth: A National Network for Microelectronics Education and Workforce Development, SEMI & American Semiconductor Academy at 6 (2022).

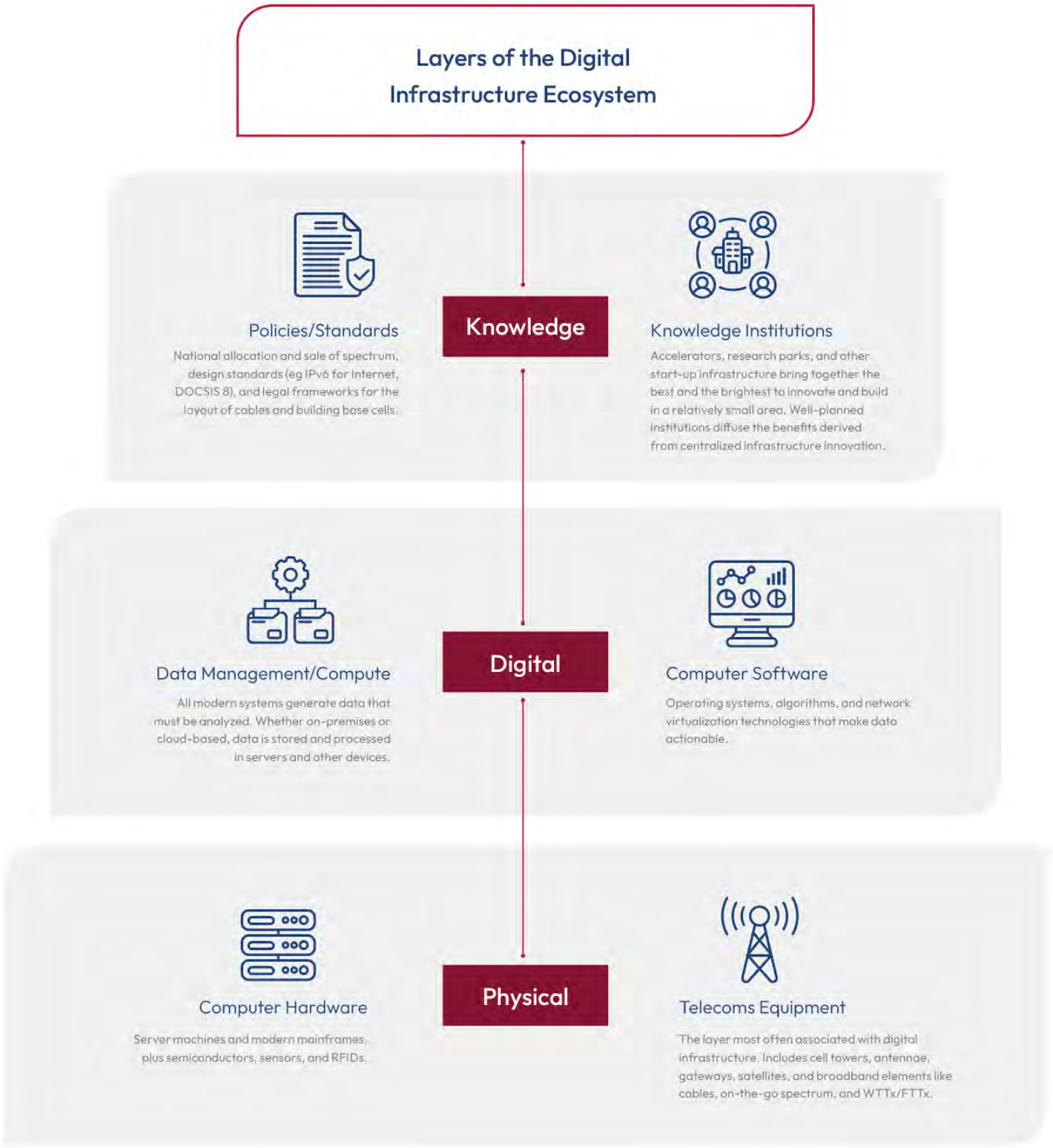
[142] See Pub. L. 117-167, The CHIPS and Science Act of 2022 (2022).

[143] Final Report, National Security Commission on Artificial Intelligence at 177-179 (2021). See also Will Hunt, Reshoring Chipmaking Capacity Requires High-Skilled Foreign Talent: Estimating the Labor Demand Generated by CHIPS Act Incentives, Center for Strategic and Emerging Technologies (2022).

Chapter II: Pipes

Technologies driving 21st-century economic growth rely on digital infrastructure – including fiber optic cables, 5G and 6G wireless networks, satellite arrays, and data centers – to connect and power them. As President Dwight Eisenhower launched the Interstate Highways System in 1956 to transform America's physical connectivity, generating hundreds of billions in economic value,[144] America today must upgrade its digital highways nationwide. The United States can pave the way for a digital economy and society via swift investment in secure domestic digital infrastructure, the removal of unnecessary regulatory hurdles, and public-private partnerships that foster private sector driven innovation. Ensuring rapid diffusion of secure digital connectivity will promote broad-based growth that can benefit all Americans and maximize America's comparative advantage in distributed innovation. The private sector is best placed to drive such innovation, but a strategic U.S. Government vision and ample financial support for basic research and world-class connectivity are crucial to maintaining the country's technological excellence.

[144] Hailey Phelps, When Interstates Paved the Way, Federal Reserve Bank of Richmond (2021).


Layers of the Digital Infrastructure Ecosystem
Knowledge
Policies/Standards
National allocation and sale of spectrum, design standards (eg IPv6 for Internet, DOCSIS 8), and legal frameworks for the layout of cables and building base cells.
Knowledge Institutions
Accelerators, research parks, and other start-up infrastructure bring together the best and the brightest to innovate and build in a relatively small area. Well-planned institutions diffuse the benefits derived from centralized infrastructure innovation.
Digital
Data Management/Compute
All modern systems generate data that must be analyzed. Whether on-premises or cloud-based, data is stored and processed in servers and other devices.
Computer Software
Operating systems, algorithms, and network virtualization technologies that make data actionable.
Physical
Computer Hardware
Server machines and modern mainframes, plus semiconductors, sensors, and RFIDs.
Telecoms Equipment
The layer most often associated with digital infrastructure. Includes cell towers, antennae, gateways, satellites, and broadband elements like cables, on-the-go spectrum, and WTTx/FTTx.

Digital Infrastructure Foundations for the Future

Since 2018, the federal government has appropriated more than $100 billion to expand broadband internet connectivity programs, including $65 billion in the 2021 Infrastructure Investment and Jobs Act (IIJA).[145] The challenge now is not just investing those funds to provide all Americans meaningful connectivity,[146] but also laying a foundation for next-generation networks needed to support innovation, bolster advanced industries, and create broad and inclusive prosperity.

Key Actions:

- *The United States must develop a national digital infrastructure strategy that encompasses wired and wireless network and computing technologies.* Federal broadband connectivity funding is fragmented across dozens of programs and agencies and lacks coordination under a single strategy.[147] America needs a comprehensive framework rationalizing these programs to provide high-quality broadband connectivity while planning for future upgrades to U.S. networks, including by promoting more competition among providers. This strategy should address how best to integrate fiber optic networks, 5G and 6G wireless platforms, and satellite and other non-terrestrial networks (NTN);[148] infrastructure needs of social institutions such as education and healthcare; and energy and climate implications and security requirements of next-generation networks.

- *The United States must upgrade its wired connectivity infrastructure – not only for broadband internet access now, but to meet future network needs, including for 5G and 6G wireless networks.*[149] The majority of U.S. broadband internet connections today run through legacy coaxial and DSL cables – a stark contrast to China, where fiber optic cable networks serve over 94 percent of broadband subscribers.[150] Upgrading to fiber or other advanced cabling materials provides far faster, more scalable, more energy-efficient links over longer distances.[151] It will also be necessary to provide more supporting backhaul connectivity to 5G and 6G networks and edge devices, particularly as private networks and Internet of Things (IoT) devices become more widely adopted.

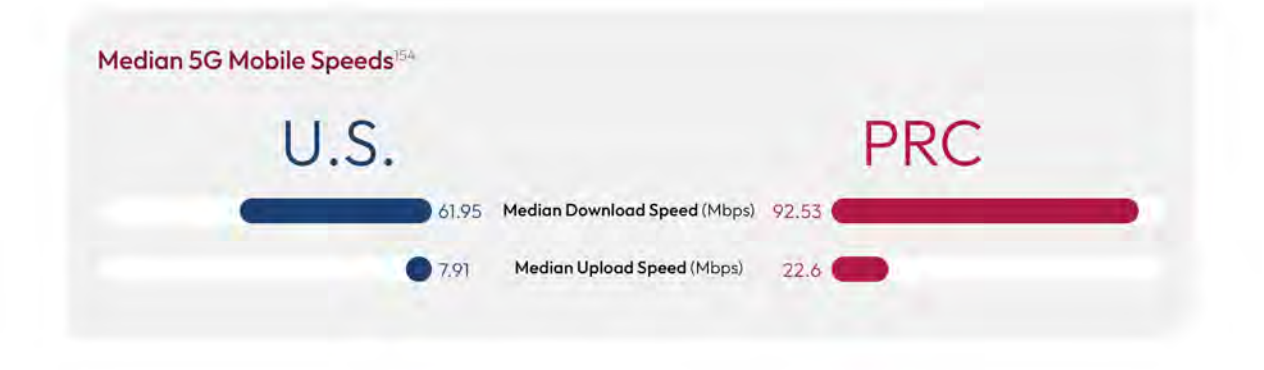
- *FCC and NTIA should fund more 5G fixed-wireless access (FWA) and satellite-based last-mile broadband services, which can be deployed more cheaply and quickly than fiber in*

[145] Fact Sheet: Department of Commerce's Use of Bipartisan Infrastructure Deal Funding to Help Close the Digital Divide, U.S. Department of Commerce (2021); Diana Goovaerts, Finding the Money: A U.S. Broadband Funding Guide, Fierce Telecom (2021).
[146] Meaningful connectivity is defined as regular digital service with access to sufficient data at fast speeds, using appropriate devices. See Sonia Jorge, It Is No Longer Enough Just to Be Online: It's Meaningful Connectivity that Transforms Lives, Alliance for Affordable Internet (2022).
[147] GAO-22-104611, National Strategy Needed to Guide Federal Efforts to Reduce the Digital Divide, U.S. Government Accountability Office (2022).
[148] For more information, see the section on Satellite Connectivity below.
[149] Marguerite Reardon, Why Fiber Is the Key to Getting Faster 5G Everywhere, CNET (2022).
[150] 2021 Statistical Bulletin of the Communication Industry, Ministry of Industry and Information Technology of the People's Republic of China (2022).
[151] Understanding the Difference - Cabling Fiber Optics Vs Copper, Versitron (last accessed 2022).

rural areas. Such funding would not only increase broadband access to underserved communities – provided these connections meet minimum performance and security standards – but would also support the development of promising new technologies, such as satellite connectivity, where the United States has opportunities to lead.

5G and Advanced Wireless Networks

Fifth- and sixth-generation (5G and 6G) wireless networks promise to unlock applications in smart manufacturing, autonomous vehicles, and other uses foundational to the next-generation economy, and could help bridge the digital divide through increased wireless broadband access. They can also make available more sources of training data for AI. The United States lags behind the PRC and peer economies in 5G network quality metrics, such as mobile speeds, and PRC state-backed telecom equipment vendor Huawei took an initial global market share lead in 5G telecommunications networks. Yet no single firm or country has won the ongoing race to develop 5G technologies,[152] and the contest to develop 5G applications is just beginning. The United States has the potential to lead the world in 5G applications by harnessing its advantages in distributed innovation, software, and open architectures.[153]



Key Actions:

- *U.S. authorities must make more radio spectrum available for 5G telecom networks as well as for smaller firms and private and city-scale 5G networks and testbeds.* A major bottleneck for further deployment of 5G is the lack of radio spectrum available for non-government uses. The United States continues to lag China and peer economies in the amount of licensed mid-band spectrum available for commercial 5G networks.[155] The

[152] Patenting Activity by Companies Developing 5G, U.S. Patent and Trademark Office (2022).
[153] Jon Pelson, Wireless Wars, Benbella Books (2021).
[154] China Median Country Speeds August 2022, Speedtest Global Index (2022); United States Median Country Speeds August 2022, Speedtest Global Index (2022).
[155] Janette Stewart, et al., Comparison of Total Mobile Spectrum in Different Markets, Analysys Mason at 10-11 (2022). "In most of the world, the frequencies between 3 GHz and 4 GHz, called mid-band, were not being used extensively, while in the US they were used by satellite communications providers and the military. This allowed Chinese manufacturers to build 5G equipment for their vast domestic use and export it internationally." See Craig S. Smith, How the Huawei Fight is Changing the Face of 5G, IEEE Spectrum (2021).

Department of Defense has objected to planned spectrum releases that it deemed could affect military operations[156] but recently released some mid-band spectrum for 5G auctions[157] and is exploring greater spectrum sharing with the private sector. Both are promising steps to address long-running disputes over spectrum, but more should be done.[158] Federal agencies[159] should release more spectrum for commercial use through both expanded spectrum sharing and auctions under a modernized spectrum allocation regime.[160] Releasing more spectrum that can be used more flexibly will foster distributed domestic innovation and provide economic and strategic benefits.[161]

- *The U.S. Government should accelerate development of the whole-of-government National Spectrum Strategy,[162] and improve the spectrum allocation process.* U.S. authorities should update spectrum allocation and governance to reflect growing demand for spectrum and new techniques for spectrum sharing. The National Telecommunications and Information Administration (NTIA) and Federal Communications Commission (FCC) must update processes and information technology systems used to manage spectrum transfer to the private sector, both for commercial space and terrestrial networks, to increase efficiency and to facilitate greater spectrum sharing as demands increase.[163]

- *Direct spectrum auction proceeds into network infrastructure and research.* Telecom and technology firms have spent around $230 billion to purchase spectrum for domestic wireless communications networks from the U.S. Government[164] – leaving them with less money to invest in top-of-the-line network infrastructure. Congress should require that some spectrum auction proceeds that the government has collected be reinvested directly into network infrastructure, management, and research, including to expand advanced wireless networks in underserved regions.[165]

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[156] John R. Hoehn, et al, Overview of Department of Defense Use of the Electromagnetic Spectrum, Congressional Research Service at 32, (2021).
[157] 3450-3550 MHz, National Telecommunications and Information Administration (last accessed 2022).
[158] John Sherman, Remarks at 2022 NTIA Spectrum Policy Symposium, National Telecommunications and Information Administration at 42-43 (2022).
[159] While FCC administers privately-held spectrum and auctions, NTIA manages federal spectrum, the largest portion of which is owned by DoD. Agencies including FAA, NASA, NOAA, NSF, and DHS also own spectrum. Spectrum Management, National Telecommunications and Information Association (last accessed 2022).
[160] One legislative proposal before Congress is the Spectrum Innovation Act of 2021 which proposes making more spectrum available to "non-Federal" entities and reauthorizes FCC's spectrum auction authority. See H.R.5378, Spectrum Innovation Act of 2021 (last accessed 2022).
[161] Joe Kane, Why We Should Stop Worrying and Learn to Love Spectrum Windfalls, Information Technology & Innovation Foundation (2022); 2022 NTIA Spectrum Policy Symposium, National Telecommunications and Information Administration (2022).
[162] National Spectrum Strategy, National Telecommunications and Information Administration (last accessed 2022).
[163] GAO-22-104537, Spectrum Management: NTIA Should Improve Spectrum Reallocation Planning and Assess Its Workforce, U.S. Government Accountability Office (2022).
[164] Roslyn Layton, Spectrum Auctions have Raised $230 Billion; The FCC's Authority To Conduct Them Will Lapse Soon If Congress Doesn't Act, Forbes (2022); Completed Spectrum Auctions, U.S. Federal Communications Commission (last accessed 2022); 2022 NTIA Spectrum Policy Symposium, National Telecommunications and Information Administration (2022).
[165] Spectrum auction proceeds largely have been directed to the U.S. Treasury, with smaller portions to U.S. agencies surrendering control of auctioned spectrum bands via the Spectrum Relocation Fund, next-generation emergency

- *Research, test, and allow more spectrum sharing using cutting-edge AI/ML tools.* The United States should aim to lead the world in researching and adopting AI/ML-driven spectrum-sharing practices among discrete users to maximize usage efficiency in an increasingly crowded spectrum landscape.

5G Applications and Private Networks

Much of 5G's promise lies in development of private, locally-configured networks where firms and municipalities develop and run enterprise applications. The United States has staked out an advantage by releasing more unlicensed radio spectrum than any other country in the world, which allows distributed innovation as firms, researchers, and other organizations can set up private 5G networks, with multiple users accessing the same spectrum band.[166] The FCC has designated several 5G testbeds as "Innovation Zones,"[167] but more are needed, particularly for sector-specific experimentation in manufacturing, agriculture, logistics, and autonomy and robotics.

Key Actions:

- *The U.S. Government should accelerate and increase funding and partnerships for R&D of enterprise-scale, private 5G applications, and smart city technologies, fostering greater knowledge diffusion among U.S. firms and municipalities.* Sectors ripe for 5G private network innovation partnerships include healthcare, manufacturing, and logistics, including as part of smart city networks. Federal funding for existing 5G innovation zones should be doubled, from $50 to $100 million, with focus placed on sustainable, private sector-driven development and commercialization of applications. Government sponsors should create wireless research spaces with low barriers to entry for researchers and small firms.

- *Strengthen the Citizens Broadband Radio Service (CBRS) for private networks.* Firms and researchers have begun launching private, independently configured 5G networks through the CBRS, which allows them to access spectrum owned by DoD without purchasing a license.[168] The FCC should explore expanding this program to facilitate more private networks, whether through additional spectrum, stronger spectrum access guarantees, higher power limits, or other improvements.

- *DoD should share non-sensitive lessons learned with private sector counterparts from its testing of private 5G networks and applications at its installations.* The Department of Defense has committed $600 million to testing and prototyping enterprise 5G network applications on its installations, including for logistics and other use cases with applicability

response, and other uses. Mark Lowenstein, Do Something Useful with Spectrum Auction Proceeds, Fierce Wireless (2021).

[166] Janette Stewart, et al., Comparison of Total Mobile Spectrum in Different Markets, Analysys Mason at 4 (2022).

[167] FCC Establishes Two New Innovation Zones, U.S. Federal Communications Commission (2021).

[168] 3.5 GHz Band Overview, U.S. Federal Communications Commission (last accessed 2022).

in the private sector.[169] DoD should develop a systematic, secure means of sharing its lessons learned with U.S. private sector partners to foster diffusion of its discoveries.

- *Firms and cities should be offered challenge grants or other incentives for piloting private 5G networks, sharing best practices with other organizations, and developing joint standards.*

Open RAN for 5G and 6G

As rollout for 5G networks and applications continues, U.S. stakeholders should look ahead to next-generation architectures and networks and lead on technology and standards setting, in cooperation with allies and partners in international standards bodies. Open radio access network architectures (Open RAN) allow users to configure and program their own networks, offer interoperability between components from different vendors, and move networks toward virtualized, cloud-based platforms where U.S. firms have advantages. Yet using open and programmable 5G networks and Open RAN also may add complexity and security risks for end users.[170] PRC firms like Huawei have expressed opposition to open architectures,[171] which threaten their end-to-end integration model that limits the competition to a small number of large companies. Early development and testing of Open RAN will allow stakeholders to shape international standards and address security vulnerabilities early in its use.

Key Actions:

- *With new funding from the CHIPS and Science Act, the U.S. Government should expand support for Open RAN testbeds.*[172] As part of this effort, Commerce and the FCC should explore catalyzing domestic production of key components (antennae, radios, etc.) through government procurements for private 5G networks, incentives, and restrictions on PRC-made components.

- *To facilitate adoption of open wireless network architectures, the U.S. Government should convene firms developing these technologies to create a certification center* to verify interoperability and security of components and software applications. U.S. stakeholders should collaborate with allies and partners to harmonize standards across like-minded countries.

Satellite-Based Connectivity

The renewed commercial viability of low-earth orbit (LEO) satellite internet could redefine the next generation of wireless communications technology by expanding Internet access and fostering new frontier innovations. U.S. firms plan to launch thousands of LEO satellites in the coming decade that will expand internet access to remote populations and pave the way for autonomous vehicles and other emerging technologies. Beyond commercial applications, the

[169] Department of Defense Hosts Ribbon-Cutting for 5G Smart Warehouse Network, U.S. Department of Defense (2022).
[170] Open RAN: Controversy and Expectations, Telecom Review (2021).
[171] Matt Kapko, Huawei CTO Disses Virtualized, Open RAN, SDX Central (2021).
[172] Pub. L. 117-167, The CHIPS and Science Act of 2022 (2022).

geopolitical implications of satellite Internet are becoming increasingly clear: the Ukrainian government has relied on U.S. satellite internet provider Starlink to maintain parts of the country's communications infrastructure amid Ukraine's ongoing conflict with Russia.[173] The PRC is launching its own LEO firms to compete in the sector,[174] making it more urgent for the United States to strengthen its lead.

Key Actions:

- *The U.S. Government should promote satellite internet, in which U.S. firms are global leaders,* by establishing a unified, less burdensome regulatory framework that streamlines spectrum allocation, deconflicts constellation deployments, reduces permitting fees and wait times, and mitigates risks posed by space-based debris. The U.S Government can also provide development and export financing for satellite connectivity services in foreign countries and expand connectivity across the Global South. These efforts serve to promote both U.S. exports and trusted digital infrastructure globally, provided they are done in compliance with U.S. export and technology controls.[175]

- *The U.S. Government should continue to modernize its Global Positioning System (GPS) and encourage partner nations to adopt GPS as their preferred global navigation satellite system (GNSS).* Launched for U.S. military use in the 1980s, the commercialization of GPS has generated $1.4 trillion in economic benefits across industrial sectors and fostered a new generation of GPS-enabled technologies.[176] The emergence of alternative GNSS such as China's Beidou system and its growing adoption among many emerging markets[177] means that, over time, these systems may start to eat away at GPS's global market share.

Computing and Data Resources

Data will fuel growth and innovation across all sectors. While U.S. tech firms lead the world in data innovation, America's fragmented regulatory landscape and lack of strategic vision threaten its advantages.[178] Meanwhile, the PRC has identified data as a new "factor of production" and developed ambitious national strategies to capture its economic value.[179]

Key Actions:

- *The United States should leverage, securely, America's datasets as an asset for its economy while protecting its citizens.* An American approach to data should serve citizens and offer a model of democratic, innovation-friendly data governance, differentiated by use case and source. It should enact federal personal data privacy rights legislation and

[173] Yaroslav Trofimov, et al., Ukraine Leans on Elon Musk's Starlink in Fight Against Russia, Wall Street Journal (2022).
[174] Translated by David Dorman, Jiutian MSI: China Must Address Threat Posed By Foreign Low-Orbit Broadband Satellite Networks; Russia-Ukraine War Increases Urgency, Digital China Wins the Future (2022).
[175] Satellite Export Control Regulations, U.S. Office of Space Commerce (last accessed 2022).
[176] Alan C. O'Connor, et al., Economic Benefits of the Global Positioning System (GPS), RTI International (2019).
[177] Yen Nee Lee, China Races to Rival the U.S. with its Own GPS System - But One Analyst Says It Won't Overtake the U.S. Yet, CNBC (2021).
[178] Cillian Kieran, Divided We Fall: Why Fragmented Global Privacy Regulation Won't Work, VentureBeat (2021).
[179] Lindsey Gorman, China's Data Ambitions, National Bureau for Asian Research (2021).

determine how to harness data to spur private sector-driven innovation and growth, including via responsible AI development. The United States should also identify anonymized datasets from enterprise and city-scale networks and various industrial applications that can be leveraged for broader economic benefit.

- *The U.S. Government should make public computing and data resources available through a National Research Cloud (NRC)*[180] *to small firms as well as academic researchers, allowing them to take advantage of pooled resources to innovate.*[181] Researchers and entrepreneurs may lack access to hyperscale computing and datasets only accessible via high-cost, proprietary cloud services. U.S. authorities should quickly stand up a NRC to provide them with large-scale training datasets for AI and high-powered resources to unlock innovations.[182] The National AI Research Resource (NAIRR) task force has developed detailed interim recommendations for creating a federated NRC specifically for AI research.[183] U.S. policymakers should stand up this resource expeditiously, with the goal of expanding innovation and economic opportunity in AI and other applications.

Security and Resiliency

Digital infrastructure must be able to provide meaningful connectivity amid a growing array of cyberattacks, extreme weather events, and other disruptions, and must rely on trustworthy components fueled by reliable, affordable energy sources. The nation must plan for network resiliency and security as integral features of its digital ecosystem.

Network Security

5G and 6G, IoT, and other advanced networks represent additional cybersecurity challenges already exacerbated by America's reliance on the PRC for network hardware components.[184] While 5G can offer security enhancements including encrypted data and segmented networks, the increase in networked devices creates more targets and potential for disruption.[185] U.S. authorities must ensure cybersecurity is designed and built into network infrastructure with trustworthy hardware components, rather than only seeking to address security at the software layer.

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[180] The NSCAI recommended creating a National AI Research Resource (NAIRR) as a national research cloud for AI. See Final Report, National Security Commission on Artificial Intelligence at 191 (2021).
[181] To "democratize access," the NAIRR Task Force was created to investigate the feasibility of establishing "a shared computing and data infrastructure that will provide AI researchers and students across scientific fields and disciplines with access to compute resources and high-quality data." See The National Artificial Intelligence Research Resource Task Force (NAIRRTF), U.S. National Artificial Intelligence Office (last accessed 2022).
[182] Stephen Ezell, A New Frontier: Sustaining U.S. High-Performance Computing Leadership in an Exascale Era, Information Technology & Innovation Foundation (2022).
[183] NAIRR Task Force, Envisioning a National Artificial Intelligence Research Resource, National Science Foundation and Office of Science and Technology Policy at 2-1 to 2-3 (2022).
[184] Potential Threat Vectors to 5G Infrastructure, U.S. Department of Defense (2021).
[185] Sara Brown, 5G, Explained, MIT Sloan School of Management (2020).

Key Actions:

- *With the growth of open-source hardware, the U.S. Government should create a Center for Open Source Technology Security to identify and catalog critical open-source software and hardware in need of support and fund improvements in cybersecurity.* The United States has promoted openness and interoperability in digital networks, and open-source solutions have created significant economic opportunities for U.S. firms. Yet open-source technology poses novel security risks and creates a "tragedy of the commons" wherein no one actor is responsible for fixing security vulnerabilities.[186] To address this, the U.S. Government should offer to provide more support to these generally volunteer efforts to quickly address software vulnerabilities identified in open-source tools.

- *U.S. authorities should set strong minimum rules and certification procedures for IoT device security.* The growth of IoT devices, ranging from industrial sensors to home appliances, vastly increases the attack surface for cyber threats deep into American homes and businesses. While Congress enacted minimum security standards for U.S. Government-owned IoT devices in 2020,[187] America lacks consistent standards for non-government and commercial use cases. Policymakers should set clear standards and identify or create bodies to certify devices to avoid a race to the bottom of cheap, non-secure devices, working with allies and partners to align these standards and share best practices.

- *Congress and FCC should fully fund and swiftly implement the requirements of the Secure and Trusted Communications Networks Act of 2019 to remove problematic components, including those made by Huawei and ZTE, from U.S. telecommunications infrastructure.*[188] FCC should upgrade rules to require telecoms to replace network components using only 5G (rather than 4G) network infrastructure.

Energy for Digital Infrastructure

The proliferation of energy-dependent digital devices and platforms, data centers, blockchain, and quantum computing will drive increased energy demand in tandem with growing energy needs in other sectors, notably increased electric vehicle adoption. This is also true of 5G networks, which may increase power consumption by up to 160 percent by 2030 due to increased density and power intensity of base station equipment.[189] Data centers supporting digital

[186] An additional vulnerability has emerged because China is "turning to U.S.-led open-source technology platforms – such as RISC-V, the Open Compute Project (OCP), and the O-RAN Alliance – as alternative vehicles to obtain the technology and expertise it needs to advance its industrial and technology goals." Karen Sutter, China's Recent Trade Measures and Countermeasures: Issues for Congress, Congressional Research Service at 42-43 (2021).
[187] Pub. L. 116-207, Internet of Things Cybersecurity Improvement Act of 2020 (2020).
[188] Congress passed the Secure and Trusted Communications Networks Act of 2019, which called for U.S. authorities to block "communications equipment or services posing national security risks" from U.S. networks, and allocated $1.9 billion to "rip and replace" suspect parts already installed. See Pub. L. 116-124, Secure and Trusted Communications Networks Act of 2019 (2019). See also Jonathan Pelson & Craig Singleton, Gearing Up for Huawei's Second Act, The Hill (2022); FCC Expands List of Equipment and Services that Pose Security Threat, U.S. Federal Communications Commission (2022).
[189] InterDigital, Wireless Energy Ecosystem Consumption to Grow by 160% by 2030, Global Newswire (2020).

networks also levy a heavy toll on energy consumption. A single data center consumes about 300,000 gallons of water per day, equivalent to about 1,000 U.S. households.[190]

Key Actions:

- *The Department of Commerce, FCC, and the Department of Energy should invest in data modeling, collection, and analysis to assess energy needs and blindspots in the nation's digital infrastructure development.*

- *U.S. stakeholders should actively research, pilot, and deploy new AI/ML tools, in conjunction with grid upgrades, to drive greater energy distribution efficiency and reliability amid dynamic demands.*

- *Federal authorities should work with state and local governments to incentivize digital infrastructure construction in the most environmentally sustainable locations without creating new regulatory barriers.*

Chapter III: People

Silicon Valley stands as the global epicenter of technology innovation and has produced many of today's leading-edge technologies. But Silicon Valley is more than just a place – it is a destination for the world's best and brightest technological talent. In recent years, however, America's tech talent pipeline has come under strain. Since 2020, U.S. engineering student enrollment has dropped by 3.5 percent, while nearly one in three American workers lacks digital skills.[191] A shortage of talent in select high-tech fields[192] could limit economic potential and create vulnerabilities for society and national security. America must invest in its workforce and develop effective education and immigration policies to ensure its leadership in the techno-economic competition and enable the economic benefits of technology to be distributed more broadly across the workforce.

Education

A skilled workforce is needed to sustain the innovation ecosystem and bring technology from the lab into widespread use.[193] But the American education system is not keeping pace with the rate of technological change, posing major risks to the U.S. economy and labor market. China has doubled down on its efforts to train domestic talent and is predicted to double America's annual

[190] Michael Copely, Data Centers, Backbone of the Digital Economy, Face Water Scarcity and Climate Risk, National Public Radio (2022).
[191] Nathan M. Greenfield, COVID-19 Drives Steep Decline in US Student Enrollment, University World News (2021); Amanda Bergson-Shilcock, The New Landscape of Digital Literacy, National Skills Coalition at 4 (2020).
[192] There is no single metric used to measure the technical workforce, but rather a variety of signals, encompassing unemployment rates, anecdotal evidence, labor market demand, and more. In general, there is a shortage of exceptional talent in high-demand fields. See Diana Gehlhaus & Ilya Rahkovsky, U.S. AI Workforce: Labor Market Dynamics, Center for Security and Emerging Technology (2021).
[193] Jeffrey Ding, The Rise and Fall of Great Technologies and Powers at 1-9 (2022).

STEM PhD graduates by 2025.[194] The quality of PhD education in the PRC has improved as well – China is home to an increasing number of higher education institutes ranked in the top 500 globally.[195] To address the domestic demand for STEM skills, the United States should expand partnerships between industry and higher education to train the next generation of emerging technology talent, expanding outreach to underserved communities to bring a wider pool of workers into growing technology fields like semiconductor production, wireless networks, and AI.

Key Actions:

- *Use industry-recognized credentials to develop academic programs in emerging technology and high-demand fields.* The private sector leads American innovation and supports the majority of U.S. technical talent. Many tech firms have their own set of professional certifications developed for industry-specific needs. State education departments and agencies should coordinate with tech firms and universities to develop and maintain joint classroom curriculum and professional credentials that prepare and upskill workers for fast-moving emerging technology fields. For example, North Dakota State University and Dakota State University both offer a variety of technology industry professional credentials, in conjunction with accredited courses through partnerships with multiple tech firms and state and local governments.[196]

- *Leverage apprenticeship programs to provide hands-on training and fill talent gaps in deep technologies.* America comprises the world's most vibrant mix of software and AI talent, but lags behind in training the next generation of hardware engineers and manufacturing talent. Apprenticeships, a combination of paid experience and education, can train and reskill a new generation of workers in fields critical to U.S. competitiveness, such as semiconductor packaging and battery assembly.[197] The CHIPS and Science Act of 2022 provides incentives to build production facilities for microelectronics, creating a mix of jobs from semiconductor engineering positions at the PhD level to Associate's degree level positions in construction and tooling.[198] These jobs will require specific know-how and on-the-job training.

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[194] Remco Zwetsloot, Winning the Tech Talent Competition, Center for Strategic & International Studies at 7 (2021); Ryan Fedasiuk, et al., A Competitive Era for China's Universities, Center for Security & Emerging Technology at 10 (2022).

[195] China had 71 universities ranked in the top 500 in 2020, up from 23 in 2010. See Remco Zwetsloot, Winning the Tech Talent Competition, Center for Strategic & International Studies at 7 (2021).

[196] NDSU Launches Technology Training Initiative to Expand Career Pathways and Meet Workforce Needs, North Dakota State University (2022); Dakota State: The Beacom College of Computer & Cyber Sciences, Dakota State University (last accessed 2022).

[197] Although there is a shortage of research on current apprenticeship programs, the studies indicated promising results. For more see David Autor, et al., The Work of the Future: Building Better Jobs in an Age of Intelligent Machines, MIT Work of the Future (2020).

[198] Pub. L. 117-167, The CHIPS and Science Act of 2022, §102 (2022). Secretary of Commerce Gina Raimondo has noted that the CHIPS Act will create jobs for underrepresented communities, an objective highlighted in the Biden administration's Executive Order on CHIPS Implementation. See Haley Lerner, Commerce Sec. Raimondo Says CHIPS Act Will Create Jobs for Women, GBH (2022); Executive Order on the Implementation of the CHIPS Act of 2022, The White House (2022).

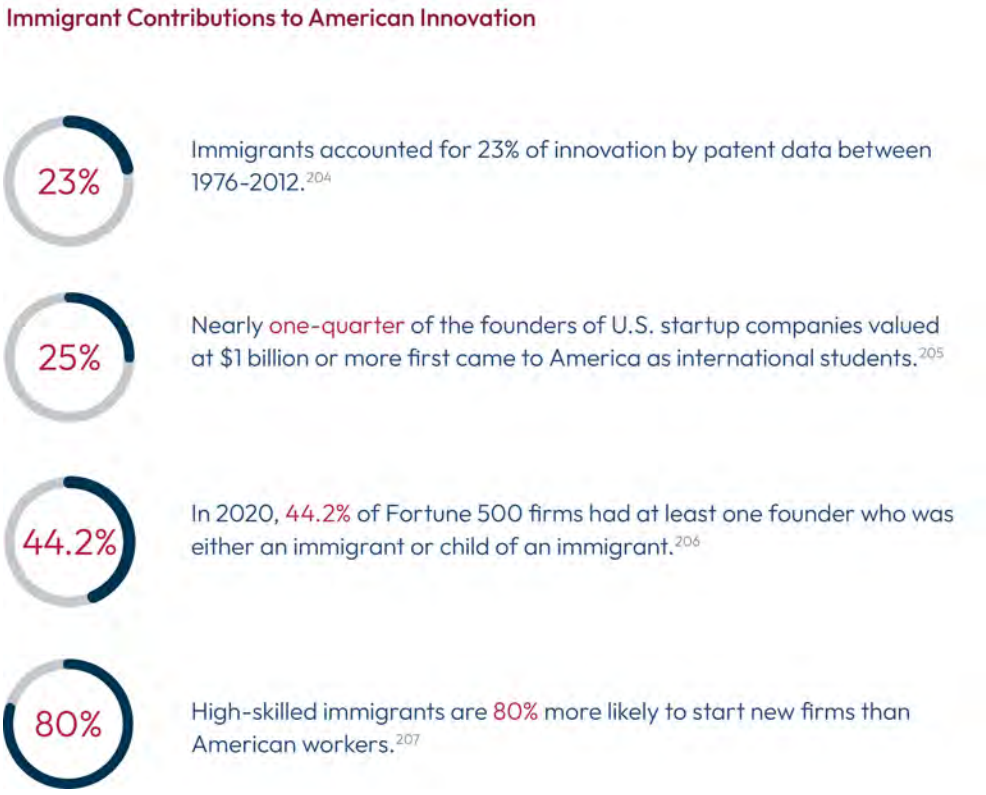
Apprenticeships provide opportunities in specialized fields and can offer industry-recognized credentials for job seekers.[199] These programs can be more cost effective for companies than offering tuition assistance,[200] and are more accessible for workers compared to high-tuition university programs. In addition, as remote work becomes more common, remote apprenticeships can also provide companies greater access to talent across the nation and offer opportunities to workers in rural regions. Congress and state governments should tailor and expand tax credits offered to firms for worker training, as well as fund novel apprenticeship programs. Currently, only 29 states offer tax incentives or tuition assistance for registered apprenticeship programs.[201] These initiatives can be especially beneficial for small- and medium-sized businesses who can only take on a few apprentices. The federal government should create a two-tiered tax credit to incentivize firms to expand and create registered apprenticeship programs. The credit would include a base amount with a higher credit for programs in high-demand industries, such as microelectronics fabrication and packaging.

- *The federal, state, and local governments must heavily invest in STEM and emerging technology education.* The National Security Commission on Artificial Intelligence recommended a National Defense Education Act (NDEA) II and a U.S. Digital Service Academy (USDSA).[202] Modeled on the original post-Sputnik legislation, NDEA II would make landmark investments in students focused on acquiring digital skills, including computer science, data science, information science, mathematics, and statistics, to build the domestic pipeline of scientists and technologists and foster additional opportunities. USDSA would be an accredited, degree-granting university that trains government civilians with digital expertise to serve across the U.S. Government's departments and agencies. To close the tech talent gap in government, America will need an established academy, and a concerted national education effort, to provide support at scale.

Immigration

Historically, the U.S. innovation ecosystem has benefited from a large number of highly-skilled immigrants, who have had a disproportionately positive impact on American innovation. These individuals helped shape the country's past and will continue to shape our future. America's long-standing status as a beacon of opportunity grants it a major advantage over the PRC as a destination for skilled technical talent.[203]

[199] The Federal Resources Playbook for Registered Apprenticeship, U.S. Department of Labor (2021).
[200] Building Strong and Inclusive Economies Through Apprenticeship, New America, Center on Education and Labor Education Policy (2019); Investments, Tax Credits, and Tuition Support, U.S. Department of Labor (last accessed 2022).
[201] State Tax Credits and Tuition Support, U.S. Department of Labor (last accessed 2022).
[202] Final Report, National Security Commission on Artificial Intelligence at 127, 175 (2021).
[203] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 12 (2022) (*SCSP-commissioned work product).*



The United States has long been the top destination for high-skilled workers and students.[207] However, that number has begun to decline.[208] Reasons for this decline vary, but U.S. institutions of higher education cite slow visa processes as the fastest growing barrier, rising from 34 percent in 2016 to 83 percent of responses in 2018.[209] These bureaucratic processes are harming the United States' ability to attract top tech talent. The proposal for a Million Talents Program[210] to attract and retain one million "tech superstars" is an example of the bold action America needs to take.

The United States should enact visa reforms to compete for top talent, choosing immigrant high-skilled workers based on need rather than lottery, redirecting "green card lottery" diversity immigrant visas towards technical talent, and creating a new "innovator visa" category.

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[204] Shai Bernstein, et al., The Contribution of High-Skilled Immigrants to Innovation in the United States, Stanford University at 1 (2019).
[205] Losing Talent 2020, NAFSA: Association of International Educators at 4 (2020).
[206] Entrepreneurship, New American Economy (last accessed 2022).
[207] Ashley Brown & Greg Brown, Why America Needs High-Skilled Immigrants, Kenan Institute (2020); William Kerry, Global Talent and U.S. Immigration Policy, Harvard Business School at 2-4 (2020).
[208] Karen Fischer & Sasha Aslanian, The U.S. Attracts Fewer International Students, Loses Billions in Revenue. Here's Why, NPR (2021); Laura Silver, Amid Pandemic, International Student Enrollment at U.S. Universities Fell 15% in the 2020-21 School Year, Pew Research Center (2021).
[209] Emma Israel & Jeanne Batalova, International Students in the United States, Migration Policy Institute (2021).
[210] Graham Allison & Eric Schmidt, The U.S. Needs a Million Talents Program to Retain Technology Leadership, Foreign Policy (2022).

Key Actions:

- *The U.S. Government should update the H-1B visa to focus on strategic sectors and increase the H-1B cap.* Qualified applications for H-1B visas for high-skilled workers far exceed the U.S. limit of 85,000 visas.[211] The U.S. Government awards these visas through a lottery that does not reflect relative workers' skills or company needs. The U.S. Citizenship and Immigration Service (USCIS) should develop a system to select applicants offering the greatest value in strategic sectors.[212] Congress should also increase the H-1B visa cap up to 195,000 – its previous cap[213] – to meet high-skilled workforce needs while updating safeguards to protect against companies using H-1Bs to lower wages rather than fill workforce gaps. This change should also give USCIS authority to adjust the cap downward temporarily in the case of recession or high unemployment, or make other dynamic adjustments based on specific skill sets needed.

- *Provide green cards to PhD graduates from U.S. universities in strategic STEM fields.* In many cases, foreign students earning advanced degrees in critical STEM fields are unable to secure work authorization within the United States. Even if these students are granted H-1B visas, their immigration status generally does not allow them to launch or work in startups related to national security or defense. With appropriate security screenings, the United States should grant conditional green cards to foreign students upon completing a PhD program in strategic STEM sectors, the list of which can be updated annually.[214]

- *Create an "Innovator Visa" category.* The United States should consider creating an immigrant visa category, similar to the UK's and Australia's Global Talent visa programs, for world-class tech entrepreneurial talent.[215] It is in the national interest to attract skilled workers in key technology sectors where talent gaps exist. This would entail more proactive recruitment and support, and an expedited application experience for leaders in emerging technology fields able to drive and scale innovation, as well as create jobs for U.S. workers.

Research Security

The United States should ensure it remains an attractive destination for international talent while implementing commonsense precautions against illicit transfer of sensitive technologies and IP. Almost 23.1 percent of America's STEM workforce is foreign-born.[216] Yet intelligence agents and

[211] Fact Sheet: The H-1B Program and Its Impact on the U.S. Economy, American Immigration Council (2022). In 2000, Congress temporarily increased the cap of H-1B visas to 195,000 in order to deal with the overflow of applicants, but that cap has expired. Pub. L. 106–313, American Competitiveness in the Twenty-First Century Act of 2000, § 102 (2000).
[212] Canada's Comprehensive Ranking System (CRS) for high-skilled workers is a good example of a points-based system incorporating multiple factors such as education, work experience, language proficiency, and more. Six Selection Factors - Federal Skilled Worker Program (Express Entry), Government of Canada (last accessed 2022).
[213] William A. Kandel, et al., U.S. Employment-Based Immigration Policy, Congressional Research Service at 16 (2022).
[214] Final Report, National Security Commission on Artificial Intelligence at 178 (2021).
[215] Apply for the Global Talent Visa, UK Government (last accessed 2022); Global Talent Visa Program, Department of Home Affairs, Australian Government (last accessed 2022).
[216] Foreign-Born STEM Workers in the United States, American Immigration Council (2022).

military officers posing as students or researchers, as well as students co-opted by foreign adversaries to compromise or steal sensitive technologies, put U.S. national security at risk.[217] For example, the PRC's access to dual-use and other sensitive U.S. research has directly contributed to PRC advancements in lethal weapons systems such as hypersonics and deep-earth penetrating warheads.[218] In other examples, agents from Iran, Russia, and elsewhere have illicitly transferred U.S. military sensitive technology to foreign adversaries.[219] In 2020, the U.S. Government restricted visas for students and researchers who had demonstrated links to the PRC's military-civil fusion strategy; a spokesperson from the U.S. Embassy Beijing noted in July 2021 that this has affected less than two percent of PRC-origin applicants. This indicates that targeted policies can protect against attempts by foreign security services to abuse U.S. visa regimes, while still maintaining foreign talent flows.[220]

Key Actions:

- *Welcome foreign students and scientists coming to the United States for legitimate purposes while implementing risk-based filters.* The Department of State should continue to deny student visas to the small percentage of applicants with demonstrated national security risk factors, such as affiliation with the People's Liberation Army or talent programs known to be Chinese Communist Party (CCP) conduits for illicit tech transfer.[221] Risk-based filters should be regularly evaluated in an interagency process to stay up-to-date with trends in emerging and dual-use technologies and changes in adversaries' strategies.

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[217] CCP-sponsored "talent programs" can serve as covers for covert and illicit technology transfer programs. For more on People's Liberation Army (PLA) officers obscuring their military ties to conduct research collaboration in sensitive fields in the United States, students passing dual-use or export-controlled research back to the PLA, and talent programs recruiting U.S.-based researchers and scientists, regardless of their ethnicity or citizenship, see Threats to the U.S. Research Enterprise: China's Talent Recruitment Plans, Permanent Subcommittee on Investigations, U.S. Senate (2019); Alex Joske, Picking Flowers, Making Honey, Australian Strategic Policy Institute (2018). Of the roughly 600 CCP talent recruitment stations located around the world, 146 are positioned in the United States. James Jin Kang, The Thousand Talents Plan is Part of China's Long Quest to become the Global Scientific Leader, The Conversation (2020).

[218] The Los Alamos Club, Strider (2022).

[219] Jury Convicts Iranian National for Illegally Exporting Military Sensitive Items, U.S. Department of Justice (2021); International Trio Indicted in Austin for Illegal Exports to Russia, U.S. Department of Justice (2020). According to U.S. Immigration and Customs Enforcement, the largest number of ongoing counterproliferation investigation cases on controlled exports involve China, Iran, and Russia. These countries "are actively implementing a multitude of schemes to illicitly or subversively acquire and transfer export-controlled military and dual use technology and commodities, and are employing myriad schemes to circumvent U.S. export control laws," including the exploitation of U.S. academia and research institutions. Statement of Louis A. Rodi III before the U.S. Senate Committee on Finance, Foreign Threats to Taxpayer Funded Research: Oversight Opportunities and Policy Solutions at 1-2 (2019).

[220] Visa restrictions imposed in 2020 to prevent students associated with Military-Civil Fusion affected less than two percent of overall PRC student and exchange visitor visa applications, according to a U.S. State Department spokesman in 2021. Amber Wang, US Visa Restrictions 'Necessary but Don't Affect Many Chinese Students', South Morning China Post (2021). Proclamation Suspending Entry of Chinese Student and Researchers Connected to PRC "Military-Civil Fusion Strategy, NAFSA: Association of International Educators (2021). The PRC's national military-civil fusion strategy seeks to integrate the civilian economy with the military industrial base, which for the United States and its allies means that economic competition with China carries directly over into traditional national security areas. Military-Civil Fusion and the People's Republic of China, Department of State (2020).

[221] Alex Joske, Hunting the Phoenix, Australian Strategic Policy Institute (2020).

- *Implement best practices for research security.* Universities, colleges, national labs, and research institutions should implement best practices for research security, in partnership with federal agencies. Commonsense practices include reporting requirements for foreign grants, ethics and compliance training for researchers, cyber audits to protect IP, and audits of grant applications, disclosures, and affiliations.[222]

Automation

Since the dawn of the Industrial Revolution, technology has advanced to automate tasks once performed by humans. Today, America's manufacturing sector has the highest rate of automation adoption of any U.S. industry, with 17.6 percent of its workforce employed at firms using AI for automation, and that number grows when it comes to the use of robotics and specialized software.[223] The AI revolution is introducing a more dynamic form of automation capable of performing even white-collar and creative tasks. This new era of automation raises legitimate concerns about replacement of human jobs, and programs that create quality jobs and support and retrain displaced workers are urgently needed.[224] Yet historical evidence indicates that incorporating technology into industries tends to create more aggregate jobs than it has displaced and increases workers' productivity and wages over time.[225]

Ultimately, the future of automation will hinge on the decisions that policymakers, industry leaders, and workforce champions make today.[226] The United States must strengthen its programs to support and upskill workers whose jobs are altered by automation.[227] Investing in the American workforce is crucial – one case study comparing German and American manufacturing firms that adopted robotics showed that German investment in worker training and reskilling policies led to lower unemployment and more financial incentives to retain workers at those firms.[228]

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[222] The University of California, for example, has successfully implemented these practices and provides resources for other universities. See Ethics, Compliance and Audit Services, University of California (last accessed 2022); Elisa Smith, Research Security Symposium Focuses on Protecting America's Intellectual Capital, University of California (2021).

[223] Daron Acemoglu, et al., Automation and the Workforce: A Firm-Level View from the 2019 Annual Business Survey, Center for Economic Studies at 16-17 (2022).

[224] Daron Acemoglu & Pascual Restrepo, Robots and Jobs: Evidence from US Labor Markets, Journal of Political Economy (2020).

[225] Economists debate the extent to which automation will impact different kinds of occupations and the best path forward to maximizing its benefits. However, evidence shows that job creation from automation tends to offset the displacement it causes. See Conor McKay, et al., Automation and a Changing Economy Part I: The Case for Action, The Aspen Institute at 5 (2019); Kerstin Hotte, et al., Technology and Jobs: A Systematic Literature Review, University of Oxford (2022); Erik Brynjolfsson, The Turing Trap: The Promise & Peril of Human-Like Artificial Intelligence, Daedalus at 272-287 (2022); Mikell P. Groover, Automation, Britannica (last accessed 2022); Ashley Nunes, Automation Doesn't Just Create or Destroy Jobs - It Transforms Them, Harvard Business Review (2021).

[226] An econometric analysis commissioned by SCSP concluded that, in the short- and medium-term, the United States would see the greatest economic benefits from applying automation in a way that focuses on augmenting worker productivity and enabling humans and machines to work side-by-side. See Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited (2022) (*SCSP-commissioned work product).*

[227] Robert D. Atkinson found that increased automation will lead to higher productivity, more investment, and more spending. See Robert D. Atkinson, Robots and International Economic Development, Information Technology & Innovation Foundation (2021).

[228] Anna Waldman-Brown, Automation Isn't the Biggest Threat to US Factory Jobs, Wired (2022).

Key Action:

- *Develop and expand federal tax credits for worker training.* Currently, federal tax laws in America do not allow a firm to expense training or education for new jobs or roles, only for improving their skills in their current position.[229] Modifying this to include new roles would incentivize firms to invest in their technology workforce and upskill employees to work alongside technology.

Chapter IV: Project

America's world-leading financial sector, rule of law, and deep, liquid pool of investment capital generates prosperity and translates into enormous economic and geopolitical power. But the emergence of financial technologies such as central bank digital currencies (CBDCs), cryptocurrencies, and payment systems is raising questions about the long-term durability of U.S. dollar and financial system dominance.[230] It is vital that the U.S. Government lock in international financial leadership by developing innovation-friendly policies and regulations for digital assets, modernizing its payments infrastructure, and updating the government's trade finance and investment toolkit. Policymakers must also pursue digital finance policies to expand financial inclusion of underserved groups, increasing the overall health of the U.S. economy.

Digital Assets and CBDCs

Governments are increasingly seeking to regulate digital assets[231] and integrate these innovations into their financial systems, including by using CBDCs to expand financial inclusion or collect more data. The PRC, which has cracked down on cryptocurrencies, is the first major economy to introduce a CBDC through the pilot the e-CNY, a fully digital version of the renminbi managed by the People's Bank of China, and develop its interoperability with foreign CBDCs.[232] U.S. authorities have begun outlining principles for digital asset governance under the March 2022 Executive Order (E.O.) on Ensuring Responsible Development of Digital Assets,[233] and a subsequent Framework,[234] but unpredictable enforcement-based regulation of digital assets is creating uncertainty among innovators without providing consistent consumer protections. To keep pace with global developments in digital finance and maintain the private sector vibrancy in

[229] Erica York, Tax Treatment of Worker Training, Tax Foundation (2019); Publication 535 (2021), Business Expenses, U.S. Internal Revenue Service (2021).
[230] Elizabeth Economy & Darrell Duffie, Digital Currencies: The US, China, and the World at a Crossroads, Hoover (2022); Samuel Shen, et al., In China, Fears of Financial Curtain as U.S. Tensions Rise, Reuters (2020).
[231] Digital assets were initially developed to displace fiat currencies and financial intermediaries. See Satoshi Nakamoto, Bitcoin: A Peer-To-Peer Electronic Cash System, Bitcoin at 1 (2008).
[232] Jonathan Movroydis, What the Rise of China's Digital Currency Could Mean for the U.S., Stanford Business (2022). See also Ananya Kumar, A Report Card on China's Central Bank Digital Currency: the e-CNY, Atlantic Council (2022).
[233] E.O. 14067, Executive Order on Ensuring Responsible Development of Digital Assets, The White House (2022).
[234] FACT SHEET: White House Releases First-Ever Comprehensive Framework for Responsible Development of Digital Assets, The White House (2022).

fintech, the United States must develop an innovation-friendly approach to regulating digital assets and pursue CBDC development in partnership with the private sector.[235]

Key Actions:

- *Congress should establish a National Security Commission on Digital Finance (NSCDF) to study the impact of digital finance on the national security and national economic advantage of the United States.* The subject of digital finance stretches across many complex topics: banking, technology, monetary policy, geopolitics, and data sovereignty issues. There are national security implications to rapid technological development of new architectures for payment rails, identity management, data storage, and other features.[236] The NSCDF should be a Congressional commission that could help to lay the groundwork for a democratic, inclusive CBDC, with Executive and Congressional Branch guidance. It could propose policy options to accelerate experimentation with CBDC options and lay out standards for transparency, national security, and other key criteria necessary to achieve domestic CBDC goals.[237] For more on establishing a National Security Commission on Digital Finance, see Appendix C of this report.

- *The United States should provide innovation-friendly regulatory clarity for digital assets.* The U.S. private sector has led global fintech development, but a lack of clear regulation and unpredictable enforcement has created uncertainty in the market.[238] To foster innovation, ensure financial stability, and protect consumers, Congress and federal agencies should articulate sensible regulatory guidelines and regulatory authorities among agencies for cryptocurrencies, stablecoins, and other financial technologies.

- *U.S. authorities should pursue policies that increase financial inclusion through digital finance.* Fintech innovations show the potential to increase financial inclusion of marginalized groups, but these must be coupled with proper policies to promote access and protect consumers.[239] Financial inclusion should be a goal of any regulation or government involvement in digital assets and other fintech in order to diffuse the benefits of U.S. innovation.

[235] Various kinds of CBDCs exist that could be considered, including private sector currencies or stablecoins within standards set by the Federal Reserve.
[236] An NSCDF could contribute to the ongoing policy processes mandated by the E.O. on Ensuring Responsible Development of Digital Assets to present findings and make recommendations to the President and Congress on the key risks that digital finance presents. See E.O. 14067, Ensuring Responsible Development of Digital Assets , The White House (2022). For the initial framework based on the first nine reports submitted under the E.O., see Fact Sheet: White House Releases First-Ever Comprehensive Framework for the Responsible Development of Digital Assets, The White House (2022).
[237] A U.S. CBDC has the potential to promote financial inclusion, productivity, and U.S. financial leadership beyond its borders, but the Federal Reserve has said that it "does not intend to proceed with issuance of a CBDC without clear support from the executive branch and from Congress," including on what type of CBDC it should pursue, if it pursues one at all. See Money and Payments: The U.S. Dollar in the Age of Digital Transformation, Board of Governors of the Federal Reserve System at 3 (2022).
[238] Eswar Prasad, DeFi's promise of Democratising Finance Remains a Distant Reality, Financial Times (2022).
[239] Yoke Wang Tok and Dyna Heng, Fintech: Financial Inclusion or Exclusion?, International Monetary Fund (2022).

- *The United States should set international standards for CBDCs and dollar-pegged stablecoins that align with democratic values and preserve financial stability.* CBDCs could improve inclusion and efficiency within the financial system and even deepen the dollar's global role, but they also pose new cybersecurity, privacy, and financial stability vulnerabilities. The United States has a unique opportunity to set international standards for CBDCs and stablecoins as it explores its own CBDC, allowing private sector innovators to compete to develop the best technical solution for a CBDC within those parameters.

Payments Infrastructure

The U.S. dollar is involved in almost 90 percent of foreign exchange (FX) transactions, accounts for nearly 60 percent of global foreign exchange reserves, and is the most commonly used currency in global trade.[240] Yet American and foreign critics alike complain that existing dollar payments systems are too slow, inefficient, and costly,[241] even though superior payments technology operates around the world.[242] The PRC is seeking to deploy its own payments infrastructure that has the potential to reduce transaction costs relative to the dollar-based systems and gain a headstart in standards-setting.[243] This would allow the PRC to increase its intrusive data collection efforts wherever the e-CNY and PRC payments platforms are used.

Key Actions:

- *The U.S. Government should continue to improve the efficiency of dollar-based payments infrastructure to counter the PRC's renminbi-based systems.* Without innovation and updates, U.S.-led payment systems risk being overtaken by PRC alternatives that utilize new technologies to speed up payment processing. Congress and the U.S. Federal Reserve (Fed) should actively work to ensure that the FedNow instant payment service remains secure and efficient, and they should explore strategies to scale the system for international use. New technologies should also be integrated into SWIFT and CHIPS to make them more efficient and resilient. U.S. officials should also explore how to promote dollar-based and other trusted payments systems to reduce costs and increase financial inclusion in Africa, Asia, and Latin America and the Caribbean as an alternative to PRC-based platforms.

- *The United States should establish a strategic plan for payment systems in the digital economy.* This plan should address the development of data privacy standards and the safe and secure integration of fast-payment systems, CBDCs and private payment arrangements such as stablecoins – cryptocurrencies pegged to a traditional financial asset, like the U.S.

[240] Carol Bertaut, et al., The International Role of the U.S. Dollar, Board of Governors of the Federal Reserve System (2021).
[241] Kristalina Georgieva, Confronting Fragmentation: How to Modernize the International Payment System, International Monetary Fund (2022).
[242] These systems include FedWire, the Clearing House Interbank Payment System (CHIPS), and the Belgium-based Society for Worldwide Interbank Telecommunication (SWIFT) system. See also Robert Greene, Beijing's Global Ambitions for Central Bank Digital Currencies Are Growing Clearer, Carnegie Endowment for International Peace (2021).
[243] Karen Sutter, Capturing the Virtual Domain: the Expansion of Chinese Digital Platforms, National Bureau of Asian Research at 48 (2022).

dollar.[244] The U.S. government's approach should be three-pronged: harness new technologies to scale existing dollar-based payment infrastructure; introduce fintech regulations designed to protect consumers, preserve the stability of the financial system, and favor competitive innovation; and explore ways to design a CBDC consistent with American values and interests.

Finance for Tech-Related Trade and Foreign Investment

U.S. trade and investment projects economic influence abroad and helps finance needed new supply chain nodes. To retain and strengthen this advantage, the United States should modernize its financial and payments systems, as well as U.S. tools that provide strategic trade and investment financing to foreign counterparts and U.S. firms. To better compete with the PRC's heavily subsidized, bundled technology export and infrastructure packages, U.S. agencies must get better organized and direct more of their trade financing and support resources towards facilitating technology exports.

Key Actions:

- *Create a Tech Export Accelerator.* This center, housed within government or at a non-profit, would serve as a one-stop-shop for foreign buyers and U.S. tech exporters. A Tech Export Accelerator should support U.S. efforts to pursue strategic technology export and investment opportunities, galvanizing U.S. financing agencies, commercial promotion, and diplomatic advocacy tools to structure and win international tenders in partnership with U.S. tech firms. For more on the Tech Export Accelerator, see Appendix D of this report.

- *Drive more financing of technology-related exports through the U.S. Export-Import Bank (EXIM).* EXIM enjoys greater lending flexibility under the China and Transformational Exports Program (CTEP),[245] but it continues to lend largely within its legacy export industries. EXIM must begin pursuing and closing export deals for strategic digital infrastructure like advanced networks.

- *Allow more flexible lending terms for EXIM and U.S. International Development Finance Corporation-backed, technology-related exports and supply chain investments* in low and lower-middle income countries, including in Africa, Asia, and Latin America and the Caribbean. EXIM and DFC often restricts to lending at market-rate terms, even if China and even allied countries provide export and development financing to lower-income countries at below-market rates and maturities. Congress should allow EXIM and DFC to lend concessionally to buyers and partners based in developing countries for strategic exports and investments, and assume more risk in their portfolios to allow financing with existing resources.

[244] Darrell Duffie & Elizabeth Economy, Digital Currencies: US, the PRC, and the World, Hoover Institution at xxvii (2022).
[245] China and Transformational Exports Program, Export-Import Bank of the United States (last accessed 2022).

- *Boost funding for the U.S. Trade and Development Agency (USTDA).* USTDA yields $136 in U.S. exports for every dollar spent on its programs[246] – including $2.3 billion in Fiscal Year 2021 – by promoting U.S. exports through pilot programs, feasibility studies, and reverse trade missions.[247] The agency has a strong record of partnering with U.S. tech firms.

- *Expand blended financing of digital infrastructure.* The U.S. Agency for International Development's (USAID) novel Digital Invest program blends U.S. Government seed funding and risk protection with private capital to finance digital and fintech infrastructure in developing countries.[248] This programming should be expanded, both financially and geographically, as a pioneering co-financing program capable of leveraging U.S. private sector resources.[249]

- *Leverage fintech platforms to deliver financing.* Explore delivering USAID, DFC, EXIM, USTDA, and other U.S. trade and development financing through advanced U.S. payments platforms or a potential U.S. CBDC to promote global uptake of U.S. digital finance platforms while improving the efficiency of payment delivery.

Chapter V: Pushback

Strengthening America's techno-economic advantages is necessary, but not sufficient to maintain leadership in emerging technologies. The economic benefits of subsidized Chinese imports and increased trade have long obscured the growing risks of entanglement with an autocratic rival rapidly modernizing its military and accumulating techno-economic power. Beijing's distortionary policies undermine industry in the United States and other market economies, suppress innovation around the world, violate China's World Trade Organization (WTO) commitments, and cause significant harm to U.S. and allied national security, companies, and citizens.[250] The United States and its allies and partners must insulate themselves by reducing

[246] About Us, U.S. Trade and Development Agency (last accessed 2022).
[247] USTDA Generates Record Results for U.S. Exporters, U.S. Trade and Development Agency (2021).
[248] USAID Launches Digital Invest Program to Mobilize Private Capital for Digital Finance and Internet Service Providers In Developing Markets as Part of President Biden's Global Infrastructure Initiative, U.S. Agency for International Development (2022).
[249] This program currently has annual federal funding of $3.45 million to mobilize over $300 million in private capital in blended investment vehicles funding internet backbone and fintech projects in Africa. See USAID Launches Digital Invest Program to Mobilize Private Capital for Digital Finance and Internet Service Providers in Developing Markets as Part of President Biden's Global Infrastructure Initiative, U.S. Agency for International Development (2022).
[250] On the suppression of innovation: Robert D. Atkinson, How China's Policies Have Stifled Global Innovation, Information Technology & Innovation Foundation (2020). On suppression of innovation in the solar power industry: David M. Hart, The Impact of China's Production Surge on Innovation in the Global Solar Photovoltaics Industry, Information Technology & Innovation Foundation (2020). On market access restrictions: According to one estimate, the economic impact of market access restrictions and other constraints like forced joint ventures on U.S. firms amounted to $32.5 billion in lost revenue between 2013 and 2019. Testimony of Stephen Ezell before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Innovation, Technology, and Intellectual Property Concern at 24 (2022). Estimates by an independent commission found that China's state-backed IP theft and industrial espionage cost the American economy up to $600 billion annually. Written Comments on Behalf of the Commission on the Theft of American Intellectual Property to the United States Trade Representative, Commission

techno-economic entanglement with the PRC and using their collective leverage to push back. This will require strengthening existing guardrails and sharpening coercive statecraft tools while creating new ones. Working with allies and partners whenever feasible, the United States should impose costs on the PRC for its predatory policies and block Beijing's efforts to gain supremacy in critical technologies at the expense of democracies' security, prosperity, and values.

This approach should include two key objectives:

- *Denial and diversification today.* The United States and its allies and partners should seek to *deny* the flow of capital, technology, and intellectual property into the PRC when it would contribute to China's military development, undermine the competitiveness of rule-of-law economies, or enable PRC human rights abuses. This will require strengthening guardrails, including investment screening and export controls. The United States should also *diversify* critical supply chains toward allies and partners and use market access restrictions to insulate their economies from PRC distortions and strengthen collective leverage.[251]

- *Deterrence and disengagement in a crisis tomorrow.* In case of a military crisis, the United States should have options prepared for severe economic and financial sanctions that target PRC economic centers of gravity. These options should be coordinated in advance with allies and partners, and build upon the momentum generated by the U.S.-led international response to Russia's invasion of Ukraine.

Inbound Investment Screening

China's development of advanced military capabilities and its ability to challenge U.S. leadership in key technologies would not have been possible without decades of access to foreign – and especially American – capital, technology, and expertise.[252] The ability to screen and, when necessary, restrict the PRC's access to sensitive technology and intellectual property is therefore an important policy tool for slowing down Beijing's efforts to gain military and technological supremacy. Research suggests that restricting PRC merger and acquisition (M&A) activity can

on the Theft of American Intellectual Property at 3 (2018). In 2022, cybersecurity researchers estimated that a years-long PRC cyber espionage campaign had stolen trillions of dollars' worth of intellectual property from approximately 30 multinational companies in the manufacturing, energy, and pharmaceutical industries. See Nicole Sganga, Chinese Hackers Took Trillions in Intellectual Property from about 30 Multinational Companies, CBS News (2022). On job losses: Robert E. Scott & Zane Mokhiber, Growing China Trade Deficit Cost 3.7 million American Jobs Between 2001 and 2018, Economic Policy Institute (2020); David Autor, et al., The China Shock and Its Enduring Effects, Stanford Center on China's Economy & Institutions (2022); Keith Bradsher, When Solar Panels Became Job Killers, New York Times (2017).

[251] Novel plurilateral trade arrangements could take many forms and center on issues such as digital trade and trade in low carbon intensity goods. For examples of proposed approaches, see Nigel Cory, Writing the Rules: Redefining Norms of Global Digital Governance, Information Technology & Innovation Foundation (2022); Catrina Rorke, The Case for Climate and Trade, Climate Leadership Council (2022).

[252] On China's international economic strategy, see Rush Doshi, The Long Game: China's Grand Strategy to Displace American Order, Oxford University Press at 134-139 (2021). On its non-reciprocal trade policies, see Findings of the Investigation Into China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation Under Section 301 of the Trade Act of 1974, Office of the United States Trade Representative (2018). On its use of sensitive U.S. technology to advance its military and technological capabilities: The Los Alamos Club, Strider (2022); Kate O'Keefe, et al., U.S. Companies Aid China's Bid for Chip Dominance Despite Security Concerns, Wall Street Journal (2022).

slow China's technological development while posing negligible economic harm to the United States.[253] Washington has taken steps to strengthen the ability of the Committee on Foreign Investment in the United States (CFIUS) to screen and mitigate foreign investments for national security risks.[254] But given the constantly evolving nature of emerging technology, CFIUS needs to be evaluated and updated regularly to account for these shifts.

Key Actions:

- *Ensure that durable changes are made to fill gaps in CFIUS.* Executive action in September 2022 was a step in the right direction in signaling the Biden administration's intent to address a broadening set of national security risk factors and its recognition that maintaining America's technological edge is critical for national security.[255] Legislation would make these risk factors permanent.

- *Use CFIUS more aggressively to screen and, when necessary, restrict PRC investments in cutting-edge U.S. technologies.* Despite moves to strengthen CFIUS, PRC investments in cutting-edge U.S. technologies continue, as does the acquisition of sensitive U.S. IP. Biotechnology, a current source of U.S. advantage,[256] stands out: the United States sits at the technological frontier, but a strong uptick in PRC M&A activity in the U.S. biotechnology sector over the past few years reveals an aggressive effort to acquire U.S. IP.[257] CFIUS should be used to screen, mitigate, and restrict the further expansion of PRC biotechnology firms like BGI in the United States.[258]

- *Loosen the jurisdictional linkage between Foreign Investment Risk Review Modernization Act (FIRRMA) and Export Control Reform Act (ECRA), giving CFIUS the flexibility to decide*

[253] Econometric analysis and academic research suggests that blocking financial flows is likely to harm China by impeding its efforts to acquire U.S. IP, with negligible macroeconomic effects on the United States. Erik Britton, Beware of People Bearing Gifts, Fathom Financial Consulting Limited (2022); Cristina Jude, Does FDI Crowd Out Domestic Investment in Transition Countries?, Economics of Transition and Institutional Change (2018).
[254] Congress passed FIRRMA in 2018, which broadened CFIUS' review authorities to cover a wider range of investments made by foreign entities, including giving the body new powers to review noncontrolling investments in deemed critical technology sectors. In September 2022, the White House issued Executive Order (E.O.) 14083 which directed CFIUS to consider a broader set of national security risk factors in its review, such as supply chain resilience, protecting Americans' sensitive data, and, crucially, and protecting America's technological lead in critical sectors such as microelectronics, AI, and biotechnology. See James K. Jackson & Cathleen D. Cimino-Isaacs, CFIUS Reform Under FIRMMA, Congressional Research Service (2020); E.O. 14083, Ensuring Robust Consideration of Evolving National Security Risks by the Committee on Foreign Investment in the United States, The White House (2022).
[255] E.O. 14083, Ensuring Robust Consideration of Evolving National Security Risks by the Committee on Foreign Investment in the United States, The White House (2022).
[256] See, for example, Robert D. Atkinson, China's Biopharmaceutical Strategy: Challenge or Complement to U.S. Industry Competitiveness?, Information Technology & Innovation Foundation (2019).
[257] Erik Britton, Beware of People Bearing Gifts, Fathom Financial Consulting Limited (2022).
[258] Years after such transactions were not blocked by CFIUS, the results are becoming clear. In 2013, PRC genomics company BGI acquired California-based Complete Genomics, which had developed the fastest and most cost-effective gene mapping technology in the world. The transaction proceeded despite security concerns raised in a CFIUS investigation. BGI has subsequently risen to become the world's largest genetic research organization and is seeking to expand its foothold in the U.S. market. For more on BGI, including the firm's involvement in the PRC's genomic surveillance in Xinjiang, see Appendix E of this report. Steve Friess, Concerns Over Chinese Genomics Bid, Politico (2012); Alison Snyder, There's New Competition for Faster, Cheaper DNA Sequencing, Axios (2022).

for itself which technologies warrant review.[259] CFIUS faces a legal bottleneck which prevents it from blocking PRC investments in key technology sectors, as only a tool of last resort. If FIRRMA were decoupled from ECRA, and from America's export controls regime in general, CFIUS would be granted discretion to determine which technologies require review and which deals warrant possible mitigation.[260]

- *Give CFIUS jurisdiction over PRC joint ventures and similar collaborative arrangements in select U.S. emerging and foundational technology sectors.* PRC authorities often pressure U.S. businesses into joint ventures and other collaborative arrangements as a way to obtain U.S. IP without triggering a CFIUS review.[261] CFIUS should have jurisdiction over a broader range of minority position investments, particularly those involving PRC venture capital investors.[262] The Committee also should monitor investment patterns to stay ahead of these trends.

- *Broaden CFIUS screening of PRC entity purchases of agricultural land and significant real estate.* PRC investments that could pose security risks to U.S. technology and connectivity infrastructure should be screened and restricted.[263]

Outbound Investment Screening

The U.S. Government should also screen outbound investment to prevent U.S. investors from contributing, wittingly or unwittingly, to the PRC's advance in strategic technologies or military capabilities at America's expense. For example, U.S. firms participated in 58 investment deals with China's semiconductor industry from 2017 through 2020, aiding China's progress in a sector

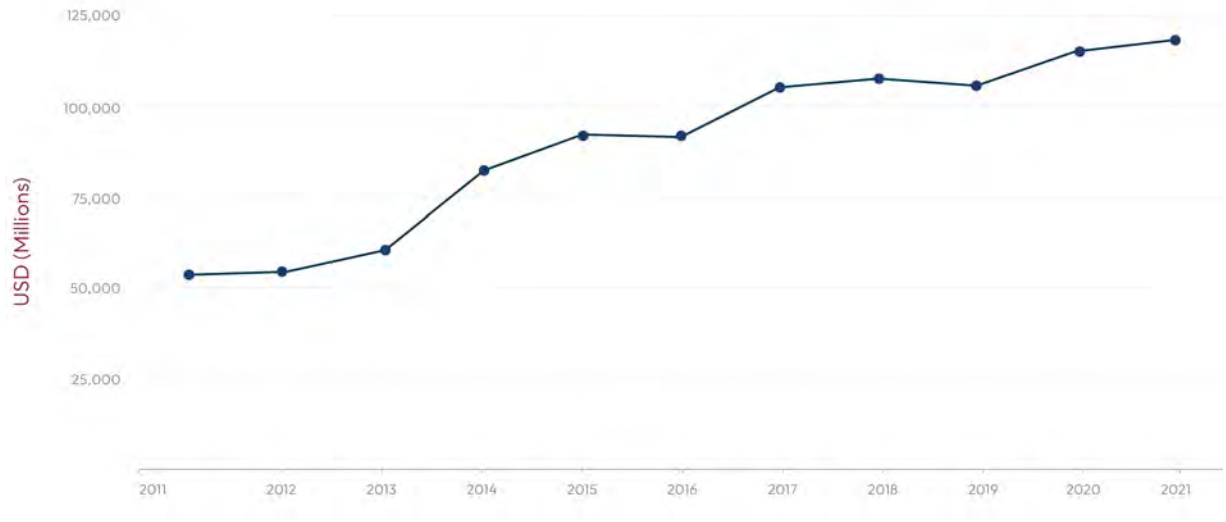
[259] Testimony of David Hanke before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Relations in 2021: Emerging Risks - Panel III: Assessing Export Controls and Foreign Investment Review at 12 (2021).
[260] Under FIRRMA, CFIUS is restricted from screening non-controlling foreign investments in technology areas unless the U.S. target company's technology has been specifically designated as a 'critical technology' by the Department of Commerce – a responsibility granted by ECRA. The slow implementation of emerging technology-related export controls under ECRA has drastically limited the Committee's jurisdiction relative to what Congress intended. See Testimony of David Hanke before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Relations in 2021: Emerging Risks - Panel III: Assessing Export Controls and Foreign Investment Review at 3-5 (2021). These restrictions hinder CFIUS's ability to move rapidly in areas where the United States is at the technological frontier, including biotechnology. For instance, it was the Commerce Department's addition of "certain nucleic acid assemblers and synthesizers" and the accompanying technology to develop the necessary software to the Commerce Control List in 2021 that in turn opened the door for CFIUS screening of those frontier biotechnologies. Chase D. Kaniecki & Pete Young, New Biotech Export Controls Expand CFIUS Mandatory Notification Requirements, Cleary Gottleib (2021).
[261] Testimony of David Hanke before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Relations in 2021: Emerging Risks - Panel III: Assessing Export Controls and Foreign Investment Review at 3-5 (2021). Hanke explains that draft FIRRMA legislation aimed to close the gap in CFIUS jurisdiction whereby a foreign joint venture partner could conduct a de-facto acquisition of a U.S. industrial capability that could have been screened – and potentially blocked – by CFIUS for national security reasons if it had been an M&A deal. But opposition from U.S. industry with significant China-based operations scuttled the proposal.
[262] Emily de La Bruyère & Nathan Picarsic, The Weaponization of Capital: Strategic Implications of China's Private Equity/Venture Capital Playbook, Foundation for Defense of Democracies at 1-2 (2022).
[263] Jenna Hoffman, China's Latest Land Purchase Could Pose Major U.S. Security Risk, Farm Journal (2022).

where it is imperative that the United States remains ahead.[264] Often, the expertise that accompanies U.S. investments, rather than funding itself, facilitates China's advance. In consultation with the private sector, the U.S. Government should establish a carefully-calibrated interagency process[265] with the authority to review and, when required, restrict transfers of technology, capital, and expertise to countries of concern, including China and Russia. As of mid-2022, both the White House and Congress were weighing the creation of such a framework.[266]

Key Actions:

- *Consider legislation to create an outbound investment screening mechanism.* In 2021, one legislative proposal for a screening mechanism was captured in the National Critical Capabilities Defense Act (NCCDA). This Act would create a process, led by the U.S. Trade Representative, to review certain types of U.S. outbound investments, information sharing, partnering, and offshoring of capabilities to countries of concern, including the PRC and Russia.[267]

U.S. Direct Investment in China[268]



[264] Kate O'Keefe, et al., U.S. Companies Aid China's Bid for Chip Dominance Despite Security Concerns, Wall Street Journal (2021).
[265] Testimony of David Hanke before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Relations in 2021: Emerging Risks - Panel III: Assessing Export Controls and Foreign Investment Review (2021).
[266] John D. McKinnon, White House Weighs Order to Screen U.S. Investment in Tech in China, Other Countries, Wall Street Journal (2022).
[267] H.R.6329, National Critical Capabilities Defense Act of 2021 (2021). See also Brian J. Egan, et al., Congress Reportedly Advances Broad Proposal for Outbound Screening of U.S. Investments in Identified Countries of Concern, Including China, Skadden (2022) and Testimony of David Hanke before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Relations in 2021: Emerging Risks - Panel III: Assessing Export Controls and Foreign Investment Review (2021). The legislation was dropped in mid-2022. See John D. McKinnon, White House Weighs Order to Screen U.S. Investment in Tech in China, Other Countries, Wall Street Journal (2022).
[268] Direct Investment by Country and Industry, 2021, U.S. Department of Commerce, Bureau of Economic Analysis (2022); International Data, U.S. Department of Commerce, Bureau of Economic Analysis (last accessed 2022).

- *Leverage existing authorities to screen outbound investments.* In the absence of Congressional action, the Executive Branch can establish a narrowly-scoped outbound investment regime via an executive order.[269] Such a process can gather information to inform later statutory requirements.

- *Consider action to address the provision of financial support – particularly managerial know-how and signaling to other peer investors – to sensitive technological development in the PRC.* Providing venture funding to a tech startup, which typically is accompanied by a board seat, strategic advice, and other support, should not be permitted if the technology in question would be subject to export controls had it been developed in the United States.[270] Action to fill this gap could include amending the Export Administration Regulations (EAR) – which regulate the export of dual-use technologies – to require a license for such support to the PRC or other foreign adversaries;[271] executive action under the International Emergency Economic Powers Act; or new legislation.[272]

- *Standardize the use of foreign adversary-focused "guardrail provisions."* [273] These guardrails should be extended beyond the semiconductor industry and other manufacturing sectors to include leading edge U.S. R&D being conducted in China, in order to ensure U.S. firms receiving federal incentives in strategic sectors do not expand their reliance on adversaries' supply chains or capital.

Export Controls

Despite the PRC's technological advancements in recent years, it remains dependent on the United States and other countries for certain technology platforms, critical inputs, and software applications, providing U.S. policymakers with significant leverage. In 2018, PRC experts self-identified 35 "chokepoints," or technologies for which China is acutely dependent on foreign suppliers.[274] U.S. leverage may be fleeting, however – as China develops indigenous capabilities,

[269] The White House can use the Presidential Emergency Economic Authorities under the International Emergency Economic Powers Act (IEEPA) to establish this process. 50 USC 35, International Emergency Economic Powers (1977); John D. McKinnon, White House Weighs Order to Screen U.S. Investment in Tech in China, Other Countries, Wall Street Journal (2022).

[270] For more on Executive branch and Congressional concern with national security risks associated with U.S. investments that offshore critical capabilities to foreign adversaries, see Testimony of David Hanke before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Relations in 2021: Emerging Risks - Panel III: Assessing Export Controls and Foreign Investment Review at 13 (2021).

[271] 15 CFR §§730-774, Export Administration Regulations, U.S. Department of Commerce (last accessed 2022).

[272] As of this writing, there is an ongoing dialogue over the preferred approach for outbound investment screening and what new authorities, if any, may be necessary. See Toomey Warns Against Establishing a Flawed Outbound Investment Regime, Senate Committee on Banking, Housing, and Urban Affairs (2022); John McKinnon, White House Weighs Order to Screen U.S. Investment in Tech in China, Other Countries, Wall Street Journal (2022). The exact legal pathway is less important provided it offers an effective, speedy, and legally robust foundation.

[273] Incentives for semiconductor manufacturing in the recently passed CHIPS and Science Act featured a novel "guardrail provision" that prohibits grant recipients from expanding their manufacturing footprint in China across leading-edge nodes. See Darryl Coote, U.S. Bars Firms with CHIPS Funding From Building Leading-edge Factories, UPI (2022).

[274] Technologies include lithography machines and underwater connectors and software, such as aviation design software and operating systems. Ben Murphy, Chokepoints: the PRC's Self-Identified Strategic Technology Import Dependencies, Center for Security and Emerging Technology at 6-9 (2022).

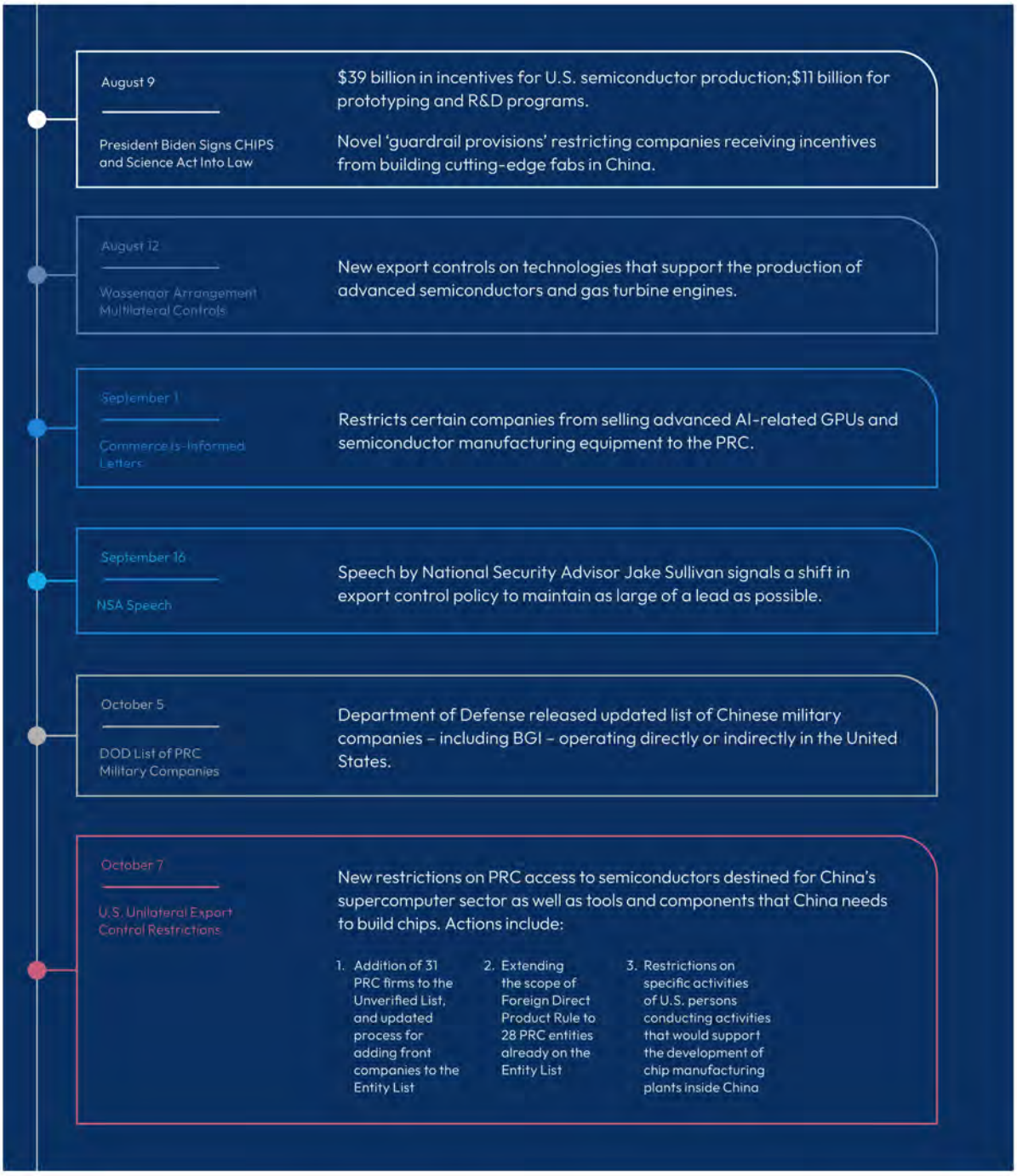
it is becoming less dependent on U.S. technology. Policymakers must also take into account that cutting off PRC access to these technologies can take time to have an impact and have uneven effects on U.S. industry. The end result is that the efficacy of U.S. export controls could diminish over time, increasing the urgency for the United States to act swiftly.

As National Security Advisor Jake Sullivan stated in September 2022, export controls can be a "new strategic asset in the U.S. and allied toolkit to impose costs on adversaries, and even over time degrade their battle capabilities." These tools, Sullivan noted, can help the United States maintain its technological advantage.[275] His remarks previewed a major policy shift from "a sliding scale approach" that sought to keep the United States only a couple of generations ahead in strategic technologies toward a more aggressive use of export controls to "maintain as large of a lead as possible" and impair China's ability to indigenously develop critical dual-use technologies.[276] His speech was a prelude to a series of actions[277] culminating in new restrictions announced in early October 2022. If implemented robustly, these restrictions will inflict significant damage on the PRC's semiconductor industry and related sectors – such as electronic design automation software, semiconductor manufacturing equipment, high-performance computing, and AI – that depend on U.S. technology and other inputs.[278]

The significance of these moves notwithstanding, gaps remain in U.S. unilateral and multilateral export control frameworks which should be addressed to protect U.S. national security and U.S. advantage in emerging technologies.[279] For specific examples of gaps that should be addressed with export controls or other U.S. policy actions, see Appendix E of this report.

[275] Remarks by National Security Advisor Jake Sullivan at the Special Competitive Studies Project Global Emerging Technologies Summit, The White House (2022). See also Ana Swanson, Biden Administration Clamps Down on China's Access to Chip Technology, New York Times (2022).
[276] Remarks by National Security Advisor Jake Sullivan at the Special Competitive Studies Project Global Emerging Technologies Summit, The White House (2022).
[277] Actions (from August to October 2022) to maintain U.S. advantage in logic and memory chips included implementation of multilateral controls on advanced compute and semiconductor manufacturing technologies and imposition of a licensing requirement on sales to China of advanced compute by NVIDIA and AMD, and semiconductor manufacturing technology by KLA, LAM Research and Applied Materials. See Commerce Implements New Multilateral Controls on Advance Semiconductor and Gas Turbine Engine Technology, U.S. Department of Commerce, Bureau of Industry and Security (2022); Reva Goujon, Running Target: Next-Level US Tech Controls on China, Rhodium Group (2022); Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China, U.S. Department of Commerce, Bureau of Industry and Security (2022).
[278] According to Gregory Allen, the Biden administration aims to (1) choke off China's AI industry by restricting access to high-end AI chips, (2) prevent its indigenous design of AI chips by denying it access to U.S. chip design software, (3) prevent China from producing advanced chips by denying it access to U.S.-built semiconductor manufacturing equipment, and (4) prevent China from indigenously producing semiconductor manufacturing equipment. Gregory Allen, Choking Off China's Access to the Future of AI, Center for Strategic and International Studies (2022).
[279] Emma Rafaelof, Unfinished Business: Export Control and Foreign Investment Reforms, U.S.-China Economic and Security Review Commission (2021).

Promoting and Protecting U.S. Technology Advantage: Key Actions August - October 2022[280]



[280] Reva Goujon, Running Target: Next-Level US Tech Controls on China, Rhodium Group (2022); Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC), U.S. Department of Commerce, Bureau of Industry and Security Press Release (2022).

Key Actions:

- *Leverage existing export controls more aggressively against additional PRC national champions, building on earlier U.S. actions.* The extraterritorial jurisdiction of the Foreign Direct Product Rule (FDPR) makes it a powerful export control tool, allowing the United States to extend restrictions in a particular sector produced with American technology, intellectual property, or other inputs. In 2020, the United States applied the FDPR to a single PRC firm, Huawei.[281] In 2022, it used the rule to sanction Russia and Belarus[282] – taking export controls a step further by applying them to a broad range of products across entire economies.[283] On October 7, 2022, the administration built on the momentum of these previous moves, applying the FDPR to 28 PRC entities which were already on the Entity List.[284] The United States should consider applying the FDPR to other PRC firms, such as its second-largest telecommunications equipment manufacturer, ZTE.[285]

- *Use sector-wide export controls to limit PRC ability to use U.S. technology and expertise to gain supremacy in critical technologies.* The United States should explore further use of the FDPR to limit PRC progress in sectors where it is racing to displace the U.S. lead, such as quantum computing.[286]

- *Redesign export controls to address the threat posed by the PRC's military-civil fusion (MCF) strategy.* Current export control approaches attempt to block the export of specific items to a particular end-user or end-use, usually a foreign military or government entity. But through MCF,[287] Beijing is working to integrate its civilian economy with its military industrial base, often rendering U.S. attempts to draw clear lines between "military" and "commercial" entities and uses in China difficult or impossible.[288]

[281] In 2020, the United States applied the Foreign Direct Product Rule to China's largest telecommunications equipment vendor, Huawei, restricting it from access to leading-edge U.S.-origin semiconductors. The action hobbled Huawei, whose share of the global telecommunications equipment market and smartphone business has since declined. Dan Strumpf, U.S. Set Out to Hobble China's Huawei, and So It Has, Wall Street Journal (2021).
[282] In response to Russia's invasion of Ukraine, the United States worked with nearly 40 countries to levy some of the harshest economic measures enacted since the Cold War, including sweeping export controls that cut off Moscow's access to microelectronics vital for advanced weaponry. See Ana Swanson, U.S. Announces Sweeping Restrictions on Technological Exports to Russia, New York Times (2022).
[283] Emily Kilcrease, Noteworthy: The New Russia Export Controls, Center for a New American Security (2022).
[284] 87 Fed. R. 62186, Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use, U.S. Department of Commerce, Bureau of Industry and Security (2022).
[285] PRC tech conglomerate ZTE was added to the Department of Commerce Entity List (EL) in 2016 for violating U.S. sanctions targeting Iran. The firm was taken off the EL in 2017 after negotiating a settlement with the United States. In 2022, a U.S. judge ruled to formally end ZTE's five-year probation that was a condition of the firm's 2017 guilty plea to the United States Government. See ZTE Corporation Agrees to Plea Guilty and Pay over $430.4 Million for Violating U.S.Sanctions By Sending U.S.-Origin Items to Iran, U.S. Department of Justice (2017); U.S. Judge Rules in Favor of China's ZTE, Ending Probation, Reuters (2022).
[286] This will be most effective for chokepoint technologies controlled largely or entirely by the United States, or where that threshold can be met by working with relevant allies and partners to establish plurilateral controls.
[287] Military-Civil Fusion and the People's Republic of China, U.S. Department of State (2020).
[288] The dual-use nature of many emerging technologies, and PRC laws that compel individuals and companies in China to assist in national security and intelligence work if required, renders further complexity to the issue. For examples of the export of U.S. technologies contributing to Beijing's military modernization, see Ryan Fedasiuk, et al., Harnessed

Furthermore, the PRC can find ways to work around U.S. rules by setting up subsidiaries, shell companies, and front companies; working through intermediaries; or establishing headquarters outside China such that rules targeting PRC entities by name or location of headquarters will not apply.[289] The United States should design new controls that block the transfer of sensitive U.S. items to all PRC companies and companies with ultimate PRC beneficial ownership – whether headquartered in China or elsewhere[290] – rather than merely targeting specific PRC end-users and end-uses.[291]

Lightning: How the Chinese Military Is Adopting Artificial Intelligence, Center for Security and Emerging Technology (2022); Ellen Nakashima & Gerry Shih, China Builds Advanced Weapons Systems Using American Technology, Washington Post (2021); The Los Alamos Club, Strider (2022). On PRC laws, see William Evanina, Keynote Remarks as Prepared for Delivery, International Legal Technology Association at 2 (2019).

[289] Cate Cadell & Ellen Nakashima, American Technology Boosts China's Hypersonic Missile Program, Washington Post (2022); Secretive Chip Startup May Help Huawei Circumvent US Sanctions, Bloomberg (2022). In another example, Huawei spun off its smartphone brand under the name Honor, to save the brand after U.S. export controls crippled Huawei's smartphone sales. Honor was able to access U.S. technology that was otherwise blocked for Huawei. Arjun Kharpal, Huawei Spinoff Honor Launches First Smartphone Overseas, Complete with U.S. Tech, CNBC (2021).

[290] That is, the United States should establish controls that apply to all of China and any company with PRC ultimate beneficial ownership.

[291] One option is to formulate policies based on the principle of "rebuttable presumption," which would presume that Beijing will use sensitive U.S. items to benefit the military if it chooses to do so, unless evidence can be shown otherwise. Such a shift would reduce the verification and compliance burden on the Department of Commerce and incentivize due diligence among U.S. entities wishing to transfer technology to China. For more on the principle of rebuttable presumption, see Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 80-81 (2022).

[292] Kevin Wolf & Emily Weinstein, COCOM's Daughter?, WorldECR (2022).

- *Lead allies and partners in the creation of a new export control regime that addresses the challenges of emerging technologies and strategic rivalry with the PRC.* The four existing multilateral export control regimes have become cumbersome and outdated, given their narrow focus on legacy Weapons of Mass Destruction and requirements for consensus from U.S. adversaries.[293] A new approach is required. It should consist of smaller, more nimble groupings oriented around specific technology sectors, such as microelectronics and semiconductor manufacturing equipment, quantum information sciences, and biotechnology.[294] Controls should be based on plurilateral agreements involving the countries with indigenous capabilities and expertise and market share in the items at issue.[295] In addition, the United States should continue to work with allies, in particular Japan and the Netherlands, to restrict the sale of high-end semiconductor manufacturing equipment to China in order to prevent democracies from contributing to the PRC's military capabilities.[296]

- *Accelerate the adoption of open-source intelligence and AI tools to streamline the Commerce Department's targeting, export licensing, and enforcement.* Sharpening the United States' economic statecraft toolkit will require the Department of Commerce to adopt a more modern and agile approach to export controls. The Department's Bureau of Industry and Security (BIS) has traditionally relied on legacy platforms for licensing, and enforcement, and a small cadre of analysts to ensure that companies comply with export controls. Integrating AI mapping and compliance tools into BIS operations will reduce the administrative burdens on personnel while enhancing the Bureau's ability to address regulatory loopholes. It would also improve coordination between licensing officers,

[293] The United States is a member of four multilateral export control regimes with other nations, including the Nuclear Suppliers Group, the Missile Technology Control Regime, the Australia Group, and the Wassenaar Arrangement. China is a member of the Nuclear Suppliers Group, and Russia is a member of the Nuclear Suppliers Group, the Missile Technology Control Regime, and the Wassenaar Arrangement. The current multilateral export control system is largely consensus-based and does not address the national security, economic security, and human rights concerns that characterize the current state of techno-economic competition. Although the existing frameworks were used to respond to Russia's invasion, they will not be successful in pushing back against PRC military-civil fusion, human rights abuses, and other contemporary concerns. See Kevin Wolf & Emily S. Weinstein, CCOCOM's Daughter?, World Export Control Review (2022).

[294] The administration could build on support for a new regime generated at the Biden Administration's December 2021 Summit for Democracy. Fact Sheet: Export Controls and Human Rights Initiative Launched at the Summit for Democracy, The White House (2021).

[295] David Hanke notes, "In the export control context, multilateral and plurilateral controls are certainly preferable to unilateral controls in most ways, especially because they help maintain a level playing field for U.S. companies. However, multilateral controls suffer from one major disadvantage as compared to unilateral controls, and that is the amount of time it can take to impose them." Testimony of David Hanke before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Relations in 2021: Emerging Risks - Panel III: Assessing Export Controls and Foreign Investment Review at 9 (2021).

[296] Stephen Nellis, et al., U.S. Aims to Hobble China's Chip Industry with Sweeping New Export Rules, Reuters (2022); Jillian Deutsch, US Wants Dutch Supplier to Stop Selling Chipmaking Gear to China, Bloomberg (2022).

export compliance specialists, and special agents, and enable verification when access is impeded.[297]

- *Strengthen licensing standards and equip the U.S. Department of Commerce to swiftly fulfill its responsibilities to identify and implement controls on emerging and foundational technologies on an ongoing basis – and give it the resources to do so.* As discussed above, ECRA was intended to modernize America's approach to export controls, but progress has been slow. Greater resources for enforcement and licensing, along with oversight and accountability, are needed.[298]

Insulating the U.S. Market from PRC Distortions

Access to America's large, diversified domestic market is a significant economic advantage for U.S. producers, even more so when combined with access to allied and partner markets. Since China's accession to the World Trade Organization in 2001, it has enjoyed largely unfettered access to the U.S. market, along with the markets of other WTO members, despite restricting foreign access to its own market in numerous strategic sectors and violating its WTO commitments.[299] The PRC's industrial policy playbook leverages subsidies, overcapacity, market access restrictions, IP theft, and other practices to sell goods internationally below market price and put foreign firms out of business.[300] To provide U.S. firms and companies from like-minded nations a market environment free from PRC distortions and large enough to be profitable, the United States and its allies and partners should use trade and economic statecraft tools to selectively restrict PRC access to their markets and deepen trade and investment with each other.

Key Actions:

[297] These capabilities could be developed in conjunction with a proposed National Techno-Economic Intelligence Center. See Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 163 (2022); Intelligence in an Age of Data-Driven Competition, Special Competitive Studies Project at 28-34 (2022).

[298] External stakeholders – such as investigative journalists, researchers, and industry groups harmed by the PRC's predatory techno-industrial practices – can highlight specific instances of the harm done to U.S. interests owing to insufficient export controls. Private-sector experts in key technology sectors could assist the U.S. Government in developing new controls which balance the need to protect national security with the evolving nature of emerging technologies and economic benefits of trade and capital flows. See Ana Swanson, Biden Administration Clamps Down on China's Access to Chip Technology, New York Times (2022).

[299] On China's failure to sufficiently open its markets to foreign competition in line with its WTO accession commitments, see USTR Releases Annual Report on China's WTO Compliance, Office of the United States Trade Representative (2022).

[300] Subsidies: Gerard DiPippo, et al., Red Ink: Estimating Chinese Industrial Policy Spending in Comparative Perspective, Center for Strategic and International Studies (2022). Overcapacity: Jeffrey Bonior, U.S. Trade Representative Calls China the "World's Leading Offender" in Creating Industrial Overcapacity, Alliance for American Manufacturing (2021). Market access restrictions: According to one estimate, the economic impact of PRC market access restrictions and other constraints like forced joint ventures on U.S. firms amounted to $32.5 billion in lost revenue between 2013 and 2019. Testimony of Stephen Ezell before the U.S.-China Economic and Security Review Commission, Hearing on U.S.-China Innovation, Technology, and Intellectual Property Concern at 24 (2022). IP theft: Estimates by an independent commission found that China's state-backed industrial espionage cost the American economy up to $600 billion annually. Written Comments on Behalf of the Commission on the Theft of American Intellectual Property to the United States Trade Representative, Commission on the Theft of American Intellectual Property at 3 (2018).

- *New authorities:* Because current U.S. and multilateral trade toolkits have proven insufficient to address the unique economic and national security challenges presented by the PRC,[301] legislation to create new authorities may be required. Collaboration among executive branch and Congressional staff, experts on national security, trade, law, and specialists in China's industrial policies and security strategies, can help generate fit-for-purpose proposals. U.S. allies and partners should also be consulted to align approaches wherever possible for maximum democratic advantage. In the meantime, the United States should leverage existing authorities more robustly, including the following:

- *Local content and country-of-origin requirements:* Policymakers could build off recent actions to block certain PRC-origin goods and services from the U.S. market, such as requirements to produce printed circuit boards domestically and electric vehicle incentives in the IRA conditioned on critical mineral production in the United States and FTA nations.[302]

- *Trade tools:* The International Trade Commission's Section 337 process could be used more aggressively to restrict market access for PRC products that have benefited from the theft of U.S. intellectual property.[303]

- *Rebuttable presumption:* A policy innovation from the Uyghur Forced Labor Prevention Act (UFLPA), the principle of rebuttable presumption shifts the burden of evidence from U.S. regulators to the U.S. person wishing to conduct an economic activity, such as importing goods from, investing in, or conducting technology cooperation with the PRC.[304] It could be applied to areas of concern beyond forced labor, such as military-civil fusion or research collaboration in sensitive technology.

- *Data security and adversary nation platforms:* The U.S. Government, in collaboration with industry partners, should develop policy concepts and technology solutions that safeguard U.S. business and personal data from being improperly collected and exploited by technology platforms operated by the PRC or other countries of concern. If existing executive branch authorities prove insufficient to address the threat posed to U.S. data

[301] In the past,the United States has used trade remedies, such as antidumping and countervailing duties investigations and tariffs, either in the WTO context or unilaterally. These may continue to be part of the solution, but on their own they have proven insufficient to insulate the United States, or its allies and partners, from PRC economic distortions. And "China has made a practice of launching antidumping and countervailing duty investigations that appear designed to discourage its trading partners from the legitimate exercise of their rights under WTO rules." 2021 Report to Congress on China's WTO Compliance, Office of the United States Trade Representative at 11 (2022).
[302] As of January 1, 2027, the U.S. Department of Defense is prohibited from acquiring printed circuit boards from countries of concern, including the PRC. See Pub. L. 117-81, National Defense Authorization Act for Fiscal Year 2022, § 851 (2021). See also Pub. L. 117-169, Inflation Reduction Act of 2022, § 13401 (2022).
[303] IP Commission 2021 Review, The Commission on the Theft of American Intellectual Property at 2 (2021); IP Commission 2019 Review, The Commission on the Theft of American Intellectual Property at 6 (2019).
[304] Pub.L. 117–78, Uyghur Forced Labor Prevention Act (2022). Operationalizing the principle of rebuttable presumption in this situation could mean that the U.S. person must show that the proposed activity does not harm national security. This could be implemented to further screen or restrict U.S. capital, technology, or know-how flows that would advance China's development of military capabilities or its systematic human rights abuses. For more on the principle of rebuttable presumption, see Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 80-81 (2022).

by adversary nations' platforms, new legal authorities should be developed.[305] The U.S. approach should be guided by at least two criteria: national security and reciprocity. National security criteria should include factors such as the ownership, control, and management of the tech platforms, the ability of third parties to audit the platform, and the scope and sensitivity of the data being collected by the platform.[306] Additional criteria should be developed to address the lack of reciprocity between U.S and PRC data regulations as a barrier to market access – an obstacle that ultimately hurt American economic and technological competitiveness.[307] Independent of any Congressional action, steps can be taken to impose data security requirements on PRC tech platforms that restrict or impose conditions on the flow of U.S.-origin data back to China that could be exploited for national security purposes or used for PRC's own technology development.[308]

- *Capital markets:* The PRC has denied U.S. regulators required transparency into its firms listed on U.S. exchanges, endangering investors and market integrity. As of September 30, 2022, 262 PRC-based firms were listed on U.S. equity exchanges, allowing them to benefit from U.S. investment capital. America's regulators should require PRC companies listed on U.S. exchanges to comply with disclosure requirements, or delist.[309]

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[305] In August 2020, President Trump issued two executive orders (E.O.s) that invoked the International Emergency Economic Powers Act (IEEPA) to seek the ban of PRC social media applications WeChat and TikTok from the U.S. market. The E.O.s were subsequently challenged in U.S. court and the courts issued preliminary injunctions, ruling that the E.O.s were unlawful and violated First Amendment rights and exceeded the government authorities granted by IEEPA, thus halting the implementation of the orders. See Christopher A. Casey, The International Emergency Economic Powers Act: Origins, Evolution, and Use, Congressional Research Service at 41 (2022). In June 2021, President Biden issued a new EO, rescinding the Trump EOs, and directing the government to further assess the security threats posed by PRC data collection via connected software applications. See Executive Order on Protecting Americans' Sensitive Data from Foreign Adversaries, The White House (2022).

[306] Specific criteria were laid out in the Executive Order on Protecting Americans' Sensitive Data from Foreign Adversaries, The White House (2022).

[307] In terms of business data, in January 2021, PRC tech firm Baidu was issued a license by the California state government to conduct road tests of its unmanned autonomous vehicles (AV), enabling the firm to collect valuable business data to refine its AV technologies. Meanwhile, U.S. firms seeking to conduct autonomous vehicle tests in China are faced with numerous regulatory barriers, and often have to form a joint venture with a PRC firm to proceed. See Jane Lanhee Lee & Munsif Vengattil, Baidu Gets Nod for Testing Empty Self-Driving Cars, Reuters (2021); Patrick Lozada, Roadblocks Along China's Route to Autonomous Vehicles, U.S-China Business Council (2017). For personal data, there are no federal data regulations requiring PRC firms operating in the United States to onshore data collected from U.S. users. The ongoing CFIUS investigation into TikTok's security practices could result in some form of data localization requirement for the PRC firm. In China, however, due to PRC data localization requirements, certain U.S. firms have had to spend upwards of $1 billion to store data collected from their PRC users inside China. See Lauren Hirsch, et al., TikTok Seen Moving Toward U.S. Security Deal, but Hurdles Remain, New York Times (2022); China's Guizhou Province to Oversee Apple's Data Project, Reuters (2017).

[308] Specific measures could include: cross-border data flow restrictions, data localization requirements, end-to-end encryption standards, source code audits, and transparency and reporting requirements. See Eric Schmidt, et al., Asymmetric Competition: A Strategy for China & Technology, China Strategy Group at 12-14 (2020); Chris Mills Rodrigo, Bipartisan Bill Targets Data Flows to American Adversaries, The Hill (2022).

[309] "Requirements" here refers to those set by the Securities and Exchange Commission (SEC). Chinese Companies Listed on Major U.S. Stock Exchanges, U.S.-China Economic and Security Review Commission (2022). In August 2022, SEC Chair Gary Gensler said that U.S. and PRC regulators were making progress toward a framework that would allow U.S. regulators to conduct required inspections and investigations but emphasized that if U.S. regulators were not able to completely audit firms in China, China-based issuers would face prohibitions on trading their securities in

Thinking the Unthinkable: Sanctions for Deterrence

In the event of a military crisis with the PRC, the United States must understand both the economic tools at its disposal and how to employ them effectively to deter Beijing's use of force or, if necessary, disengage its economy from China's. To deter PRC military aggression, and in coordination with military and diplomatic measures, the United States should signal a willingness to impose sanctions on sectors where China has external dependencies, such as key technology and industrial inputs,[310] energy,[311] and finance.[312] Given China's deep and extensive integration in the global economy, engaging in a sanctions campaign against the PRC would require significant planning, international coordination, and sacrifice.[313]

Key Actions:

- *A PRC-focused sanctions contingency plan should be coordinated in advance among the Departments of Treasury, State, Commerce, and Defense, and the Intelligence Community.*[314] Analysts could identify targets that would cause significant impact for Beijing if sanctioned but carry relatively less significance to the United States or have costs absorbable by the international community.

- *Coordinate sanctions with allies and partners.* To maximize the effectiveness of sanctions, the United States should coordinate with allies and partners in advance, building on the momentum of democratic cooperation to sanction Russia for its invasion of Ukraine in 2022.[315] The United States should coordinate policies with allies and partners such as

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the United States. Gary Gensler, Statement on Agreement Governing Inspections and Investigations of Audit Firms Based in China and Hong Kong, U.S. Securities and Exchange Commission (2022).

[310] China Is Trying to Protect Its Economy from Western Pressure, The Economist (2022).

[311] China has built up a strategic petroleum reserve to reduce its immediate exposure to pressure and its reserve is at roughly 40-50 days' worth of imports, meaning that if imports were completely cut off, it could continue to consume at normal levels for 40-50 days. Frank Tang, How Big Are China's Crude Oil Reserves and How Do They Compare to the US' SPR?, South China Morning Post (2021).

[312] China holds substantial amounts of U.S. debt, including over a trillion dollars' worth of U.S. Treasuries. Major Foreign Holders of U.S. Treasury Securities, Statistica (last accessed 2022).

[313] There is no guarantee that the threat of sanctions would deter Beijing from the use of force, but sanctions would have a greater chance of success if they were signaled early in a crisis, while Beijing is still weighing whether to take military action – underlining the importance of planning in advance, before a military contingency.

[314] The United States lacks a systematic mechanism to conduct strategic analysis and planning for sanctions. The recently-created Sanctions Economic Analysis Unit at the Treasury Department has been assigned responsibility for assessing economic spillovers from U.S. sanctions, but it is unclear whether the office will play a role in sanctions planning and coordination across the interagency. An interagency sanctions planning cell could be established to design a program for potential sanctions against PRC targets in steady-state or crisis. A government-affiliated institution or the Techno-Economic Intelligence Center (TEIC) recommended by SCSP could conduct open-source research that the government could vet and use to develop sanctions packages. See Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 163 (2022); Intelligence in an Age of Data-Driven Competition, Special Competitive Studies Project at 28-32 (2022). The TEIC could support sanctions planning in the following ways: (1) identify targets and assess existing U.S. sanctions tools to identify gaps; (2) conduct vulnerability and opportunity analysis for potential sanctions tools; and (3) propose effective responses to countermeasures that the target may adopt.

[315] Bill Bostock, Kremlin Staff Didn't Expect Putin to Invade Ukraine and Were Shocked by the Severity of Western Sanctions, Report Says, Financial Times (2022).

NATO, the European Union, AUKUS,[316] and the Quad[317] to ensure alignment in case of a contingency requiring the signaling or imposition of severe sanctions on the PRC.

Such coordination efforts – within the interagency, and with allies and partners – would be especially important as PRC leaders attempt to mitigate China's vulnerability to sanctions by developing alternative payment systems, pursuing indigenous technology capabilities, and forcing Party elites to divest assets in the West.[318] The United States and its allies should assess the effectiveness and potential implications of Beijing's sanctions-proofing efforts, as well as how to counter them.

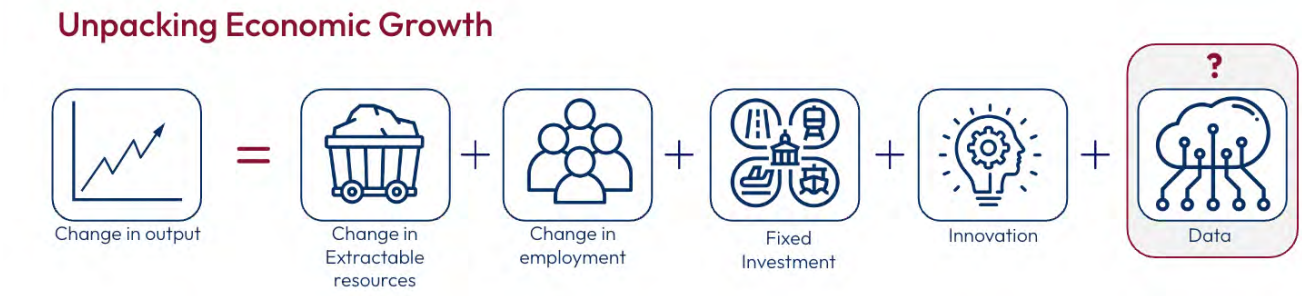
Conclusion

Technology leadership is built on an economic foundation. The United States holds massive economic advantages over China, including a world-class innovation ecosystem, the world's most dynamic and liquid capital markets, and a highly productive workforce. However, cracks are beginning to form. Talent shortages, slowing productivity growth, and the decline of U.S. manufacturing, among other trends, suggest that government action is needed. To retain technology leadership, the United States must bolster systemic factors that shape the innovation ecosystem – manufacturing capacity for critical technology inputs, technology infrastructure, workforce, and financial leadership – while pushing back against China's distortionary industrial policies. These steps should be considered in coordination with and, where possible, acted on in concert with allies and partners. Taken together, these actions constitute a techno-industrial strategy that can generate prosperity for all Americans while filling key economic and national security gaps, positioning America for long-term techno-economic success.

[316] AUKUS is a trilateral security pact that includes the United States, the United Kingdom, and Australia. Fact Sheet: Implementation of the Australia – United Kingdom – United States Partnership (AUKUS), The White House (2022).
[317] The Quad includes the United States, Japan, Australia, and India. Joint Statement from Quad Leaders, The White House (2021).
[318] Chun Han Wong, China Insists Party Elites Shed Overseas Assets, Eyeing Western Sanctions on Russia, Wall Street Journal (2022).

Appendix A:
Back to the Basics – Comparing U.S. and PRC Economic Fundamentals

The nation with a stronger economic foundation comes to the competition with inherent advantages. Economists recognize several "factors of production" (resources used to create economic growth) that provide a framework for comparing U.S. and PRC economic fundamentals:[319] **land, labor,** and **capital.** In addition, **innovation**[320] measures how well the other factors are combined. In the context of emerging technologies, **data** might be considered another factor of production.[321] Using and combining these factors productively is key to long-term economic prosperity.[322] In broad terms, the United States is better positioned in terms of both land and natural resources, and productive labor, but China has narrowed the gap in terms of physical capital. The United States commands a strong lead in innovation, but the PRC is racing to catch up.



A country's ability to deploy its public and private resources effectively is also key to prevailing in techno-economic competition. Not captured in the framework above are differences in political systems and policies, or degrees of public and private partnership, which determine how well a nation harnesses its economic fundamentals for national advantage. This framework also does not account for the force multiplying effects of working with allies and partners – an area where the United States holds a strong lead over the PRC.

[319] This assessment was informed by Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited (2022) (*SCSP-commissioned work product).*

[320] Innovation here is also referred to by economists as total factor productivity (TFP) or X-factor.

[321] Data is not traditionally included by economists as part of the definition of the "factor of production," but the CCP, seeing the economic potential of data, has revised its own economic theory to include it. See Qiheng Chen, China Wants to Put Data to Work as an Economic Resource - But How?, Stanford University, DigiChina (2022).

[322] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited (2022) (*SCSP-commissioned work product).*

Factors of Production	United States	PRC	Chapter References and U.S. Policy Recommendations
 LAND *Availability of natural resources (e.g., food, energy, and raw materials)* U.S. has the advantage	+ Net exporter of energy and food[323] + World's second largest mineral reserves[324]	+ World's sixth largest in mineral reserves,[325] and world's largest processor and refiner of rare earths[326] – ...**but** net importer of food,[327] and the world's largest net importer of oil[328]	+ Build mineral production and processing capacity in partnership with industry and international partners[329] + Accelerate stockpiling of rare earths and other strategic resources[330] + Invest in new forms of energy to mitigate the effects of carbon-induced climate change[331]
 LABOR *Availability of skilled and growing workforce* U.S. has the advantage	+ Slowing but growing working age population[332] + High productivity per capita[333] + Ability to attract leading talent from around the world[334]	+ Large population, high literacy rates, maturing educational system[335] – ...**but** working-age population is shrinking, reflecting a broader, severe demographic decline[336]	+ Invest in workforce development and training for jobs impacted by AI and automation[337] + Focus on training and educating the workforce to evolve with technology[338] + Speed immigration processes to attract international talent, and target work visas and programs[339]
 CAPITAL *Availability of physical capital (e.g., infrastructure, factories)* China is moving faster to accumulate physical capital, but the United States has a strong lead in finance	– Mixed record in aligning government and private sector strategic investments – Aging physical infrastructure[340] + Deep, liquid financial markets, leadership in finance, and dollar's status as global reserve currency offer significant advantages for funding productive investment.[341]	+ Strong track record of investments in physical infrastructure and manufacturing (e.g., data centers, chip manufacturing, etc.)[342] – ...**but** overinvestment in infrastructure has led to high corporate and local government debt, putting constraints on productivity[343] – Underdeveloped financial system with a relatively closed capital account[344]	+ Move quickly to build secure digital infrastructure[345] + Accelerate R&D for 5G applications, industrial testbeds, and smart cities[346] + Lead in fintech to maintain US financial leadership[347] + Increase the efficiency of dollar-based payment infrastructure[348] + Set the standard for a central bank digital currency[349]

 INNOVATION	+ High performing in most measures of innovation[350] + World-class R&D institutions supported by strong government, industry, and academia collaboration.[351]	+ Improving in many measures of innovation[352] **+/-** ...**but** innovation capacity remains largely centered on building off existing foreign technologies rather than inventing original technologies;[353] however, some novel breakthroughs are emerging	+ A Techno-Industrial Strategy can boost productivity, yielding spillover benefits for the entire economy[356]

[323] U.S. Energy Facts Explained, U.S. Energy Information Administration (last accessed 2022); Does the United States Import More Agriculture Products than We Export?, American Farm Bureau, Foundation for Agriculture (last accessed 2022).
[324] Craig Anthony, 10 Countries with the Most Natural Resources, Investopedia (2022).
[325] Craig Anthony, 10 Countries with the Most Natural Resources, Investopedia (2022).
[326] Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth, The White House at 9 (2021).
[327] Susan Reidy, China Hungry For More, World Grain (2022).
[328] Hannah Reale, et al, Where Does China Get Its Oil?, The Wire China (2020).
[329] See Chapter I of this report.
[330] See Chapter I of this report.
[331] See Chapter I of this report.
[332] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 15 (2022) (*SCSP-commissioned work product).*
[333] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 20 (2022) (*SCSP-commissioned work product*).
[334] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 74 (2022) (*SCSP-commissioned work product*).
[335] China, UNESCO Institute of Statistics (last accessed 2022).
[336] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited at 15 (2022) (*SCSP-commissioned work product*).
[337] See Chapter III of this report.
[338] See Chapter III of this report.
[339] See Chapter III of this report.
[340] 2021 Report Card for America's Infrastructure, American Society of Civil Engineers (last accessed 2022).
[341] Most economists do not include financial assets as part of their definition of capital in the factors of production, but we include it here since it is a relevant factor in comparing relative U.S. and PRC economic strengths.
[342] David Dorman, China's Plan for Digital Dominance, War on the Rocks (2022).
[343] Amanda Lee, China's Debt-Fuelled Infrastructure Investment Drive Sees Record 1.94 Trillion Yuan Bonds Sold in June, South China Morning Post (2022).
[344] Bernadette Lee, China's Capital Controls: Here to Stay?, Central Banking (2021).
[345] See Chapter II of this report.
[346] See Chapter II of this report.
[347] See Chapter IV of this report.
[348] See Chapter IV of this report.
[349] See Chapter IV of this report.
[350] United States of America, Global Innovation Index (2021).
[351] Steven Olson, The Endless Frontier: The Next 75 Years in Science, National Academies of Sciences, Engineering, and Medine (2020); Global Innovation Index 2022, World Intellectual Property Organization at 50 (2022).
[352] China, Global Innovation Index (2021).
[353] Welcome to the Machine: A Comparative Assessment of the USA and China to 2035 Focusing on the Role of Technology in the Economy, Fathom Financial Consulting Limited (2022) (*SCSP-commissioned work product).*
[356] See the "Toward a Techno-Industrial Strategy" section of this report.

Measures how productively other factors are combined U.S. has the advantage, but the PRC is gaining ground		**+/-** Expansive government guidance funds and PE/VC funds command massive resources, but producing mixed results[354] **+/-** Entrepreneurship is being counterbalanced by growing uncertainties amid tightening Party control[355]	
 DATA *Availability of data in terms of quantity, quality/diversity, accessibility, and depth* Slight PRC edge, although both U.S. and PRC have distinct advantages	**+** Unmatched diversity and quality of data thanks to global presence of U.S. tech firms[357] **–** Patchwork of state-level laws; lack of national data governance regime[358] **+/-** Even with PRC on data volume/quantity, though some analysts suggest PRC will take the lead by 2025[359]	**+** Unparalleled depth and PRC government access to public data thanks to ubiquity of digital services, including finance[360] **+** Ambitious digital infrastructure strategy[361] and extensive data governance regime being put into place, designed to protect and commercialize public data	**+** Develop a national approach to data that leverages America's data as an asset for its innovators[362] **+** Foster responsible artificial intelligence applications while protecting digital privacy and security[363] **+** Protect American user data by levying security requirements on PRC platforms and ensure bulk U.S. commercial data is not enabling PRC tech development without some restrictions.[364]

[354] Stewart Randall, Why is China Investigating the State-Backed Semiconductor "Big Fund"?, Technode (2022); Rick Switzer & David Feith, China Hit Some Bumps on its Road to Semiconductor Dominance, Wall Street Journal (2022).
[355] Coco Liu, et al., China's Tech Giants Lost Their Swagger and May Never Get It Back, BNN Bloomberg (2022).
[357] Matt Sheehan, Much Ado About Data: How America and China Stack Up, MacroPolo (2019).
[358] Daniel Castro, et al., The Looming Cost of a Patchwork of State Privacy Laws, Information Technology & Innovation Foundation (2022).
[359] Matt Sheehan, Much Ado About Data: How America and China Stack Up, MacroPolo (2019); David Reinsel, et al., The Digitization of the World: From Edge to Core, IDC (2018).
[360] Matt Sheehan, Much Ado About Data: How America and China Stack Up, MacroPolo (2019).
[361] David Dorman, China's Plan for Digital Dominance, War on the Rocks (2022).
[362] See Chapter V of this report.
[363] Mid-Decade Challenges to National Competitiveness, Special Competitive Studies Project at 84-95 (2022).
[364] See Chapters II and V of this report.

Appendix B:
5G Action Plan

The United States must act decisively to expand secure, high-performing 5G networks domestically, drive research, development, and piloting of 5G applications and open architectures (including Open RAN), galvanize U.S and allied public-private support for democratic technology standards, and actively pursue and win strategic technology infrastructure projects abroad.

U.S. Domestic	International	Abroad
Expanding and Securing 5G Networks **Support 5G infrastructure via broadband buildout** (including middle-mile fiber for 5G, and 5G fixed-wireless access broadband) (Commerce, FCC) **Spectrum** (NTIA, FCC) • **Release more spectrum** through both sharing and auctions for small and large firms • **Accelerate U.S. spectrum strategy** regulating and maximizing complementary terrestrial and non-terrestrial networks • **Direct spectrum auction proceeds** to investment in infrastructure • **Advance spectrum sharing technology** Expand use of **private, programmable 5G networks and on government installations and labs** (DoD) **Pursue comprehensive 5G cybersecurity**, including full implementation of Rip and Replace and assessment of Open RAN vulnerabilities (DHS, NIST, Commerce) Industrial and Public Sector 5G Applications **Identify priority sectors/applications** Work through **NIST's Manufacturing Extension Program (MEP) to identify, co-finance, and set up testbeds in key industrial sectors** Support and develop **open standards to enable Open RAN, Virtualized RAN (VRAN)** (NIST)	**Strengthen 5G standards engagement** in 3GPP (State, NIST, Commerce) **Develop formal public-private, allied convening mechanism** to align U.S., allied firms behind standards (Commerce, State) **Expand U.S. digital trade frameworks** to facilitate 5G-related digital exports, trade benefits for recipient countries (USTR, State, Commerce) **Create Open RAN interoperability certification center** (NSF, FCC, NIST)	Create **Tech Export Accelerator** to identify and pursue major tech export opportunities and align USG financing streams and advocacy. *(See Appendix D)* **Set 5G network deals as requirement/priority for EXIM/DFC** for new CHIPS foreign funding Increase seed funding for USAID-led, public-private **Digital Invest investment vehicle** Pursue deals for **5G infrastructure from trusted vendors (subsea cables, fiber backbone, data centers, satellites)** (Commerce, State, export promotion agencies) With U.S. tech firms, **develop workforce development and trade benefits to couple with 5G and 6G network offerings** **Win a proof-of-concept 5G network deal** as part of G7 Partnership for Global Infrastructure and Investment (DFC, EXIM, State, Treasury) **Extend Huawei sanctions** and apply to ZTE (Commerce, State, Treasury, NSC) Press allies and partners to use trusted vendors (State, Commerce, DOD)

Appendix C:
Establishing a National Security Commission on Digital Finance

The National Security Commission on Digital Finance (NSCDF) would conduct a thorough review of how advances in digital finance and related technologies will shape U.S. national security and economic competitiveness, provide an interim report to the President of the United States and Congress within one year, and submit a final unclassified report within two years to the President and Congress, including recommendations for action by Congress and the Executive Branch. The Commission should likely reside in the Legislative Branch.

The NSCDF might cover the following topics:

- Assessing implications for dollar centrality from growing use of the e-CNY or other currencies, including how rival digital currencies could undermine western monetary systems or otherwise create an alternate monetary system.
- Investigating the PRC's use of the e-CNY to create a global data and surveillance platform.
- Analyzing digital finance-enabled threats to U.S. influence from malign actors seeking to evade sanctions and anti-money laundering and counter-terrorism financing, including from China, Russia, Iran, North Korea, and non-state groups.
- Promoting design features in a U.S. CBDC that benefit national security while allowing fintech innovation and ease of dollar use.
- Facilitating public-private partnership to research and develop technology and standards for a U.S. CBDC and other financial technologies that would balance innovation and national security.
- Identifying tensions and opportunities between U.S. industry innovations in fintech and national security.
- Identifying financial sector vulnerabilities and opportunities posed by digital finance technology, and recommending needed upgrades to payment infrastructure
- Highlighting frameworks for working with allies, partners, and international bodies on key digital finance issues.
- Addressing key research gaps on digital finance and national security.[365]

The NSCDF would convene private stakeholders and public officials and contribute to the ongoing policy processes mandated by the Executive Order on Ensuring Responsible Development of Digital Assets and outlined by the Comprehensive Framework for the Responsible Development of Digital Assets.[366]

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[365] Darrell Duffie & Elizabeth Economy, Digital Currencies: US, the PRC, and the World, Hoover Institution (2022); Center for a New American Security in June 2022 announced a "Task Force on Fintech, Crypto, and National Security" to "develop pragmatic and innovative national security policy recommendations for the rapidly evolving ecosystem of financial technologies, crypto, digital assets, and decentralized finance (DeFi)." See Task Force on Fintech, Crypto, and National Security, Center for a New American Security (last accessed 2022).

[366] E.O. 14067, Ensuring Responsible Development of Digital Assets (2022); Fact Sheet: White House Releases First-Ever Comprehensive Framework for the Responsible Development of Digital Assets, The White House (2022).

Appendix D:
Tech Export Accelerator

The U.S. Government should establish a dedicated Tech Export Accelerator to support the development, structuring, and completion of strategic technology-related commercial transactions abroad by galvanizing U.S. financing, commercial promotion, and diplomatic advocacy tools, in partnership with U.S. tech firms. The accelerator would:

- Liaise closely with U.S. embassies and tech firms to maintain a pipeline of opportunities for government technology procurements and commercial technology infrastructure tenders abroad, offering a "one-stop shop" for firms and government officials alike.
- Maintain a dynamic database showing the status of export and investment opportunities, accessible by relevant foreign affairs and commercial promotion agencies.[367]
- Work with U.S. foreign affairs agencies to support the structuring and acceleration of export and investment bids, and liaise between U.S. and foreign officials, tech firms, and private sector financiers.
- Employ personnel solely dedicated to supporting project flow, and knowledgeable about technology sectors and U.S. commercial promotion tools.
- Train U.S. officials working abroad on identification and basic assessment of export and investment opportunities, building on existing efforts.

The United States is home to many technology firms, and the U.S. Government has numerous tools to provide loans, lines of credit, equity investments, insurance, and other support for exports and investment abroad. The U.S. Government also provides information on business opportunities abroad, such as the Business Information Database System (BIDS)[368] and U.S. Commercial Service market intelligence services.[369]

What these tools lack is a dedicated team responsible and incentivized for identifying and vetting opportunities, matching them with appropriate U.S. Government tools, and supporting U.S. bids through their lifecycle – a disadvantage compared with PRC-based firms that offer 'turnkey' tech/digital infrastructure and financing bundled into a single package.

An Export Accelerator could serve as a "one-stop shop" staffed by trained officials able to quickly assess opportunities, structure appropriate product and financing packages, and drive engagement in support of a U.S.-based bid. Initiatives launched by the Departments of State and Commerce to match U.S. firms with infrastructure tenders have struggled, and none have focused only on tech opportunities. These have struggled because no office or individual is responsible for managing project opportunities, officials lack relevant training, and financing agencies are unequipped to coordinate complex transactions across multiple U.S. agencies.

The Accelerator could be housed in a non-profit organization, as an independent government entity, or within the Department of Commerce or State, or another government agency.

[367] These agencies could include, but are not limited to, the Departments of State, Commerce, Treasury, and Defense, as well as USAID, U.S. Export-Import Bank (EXIM), U.S. Development Finance Corporation (DFC), and USTDA.
[368] Business Information Database System (BIDS), U.S. State Department (last accessed in 2022).
[369] Export Solutions, U.S. International Trade Administration (last accessed in 2022).

Appendix E:
Pushback – Closing the Gaps

Over 600 PRC entities are listed on various U.S. Government blacklists,[370] including the U.S. Department of Commerce's Entity List (EL) and Foreign Direct Product Rule (FDPR).[371] Yet policy holes exist that allow firms with track records of harming U.S. interests to continue accessing U.S. technology and expand their U.S. and global market share.

Problem	Policy Options
ZTE's absence from the Commerce EL and FDPR exposes a major gap in U.S. export controls targeting the PRC's telecommunications equipment manufacturing industry. ZTE is the PRC's second largest telecom vendor. While imposing the FDPR on Huawei – the PRC's largest telecom vendor – has stunted the firm's growth, ZTE's market share continues to rise.[372]	**Export controls:** Apply the FDPR to ZTE to diminish PRC influence over the global telecommunications infrastructure market.
Suppliers to PRC telecom giant **Huawei** and chip manufacturer **Semiconductor Manufacturing International Corporation** (SMIC) received billions of US dollars' worth of export licenses in spite of the PRC firms being subject to the FDPR and EL.[373]	**Export controls:** Change the licensing policy for the more than 600 entity listed PRC entities – including Huawei and SMIC – to "policy of denial" rather than presumption of denial.

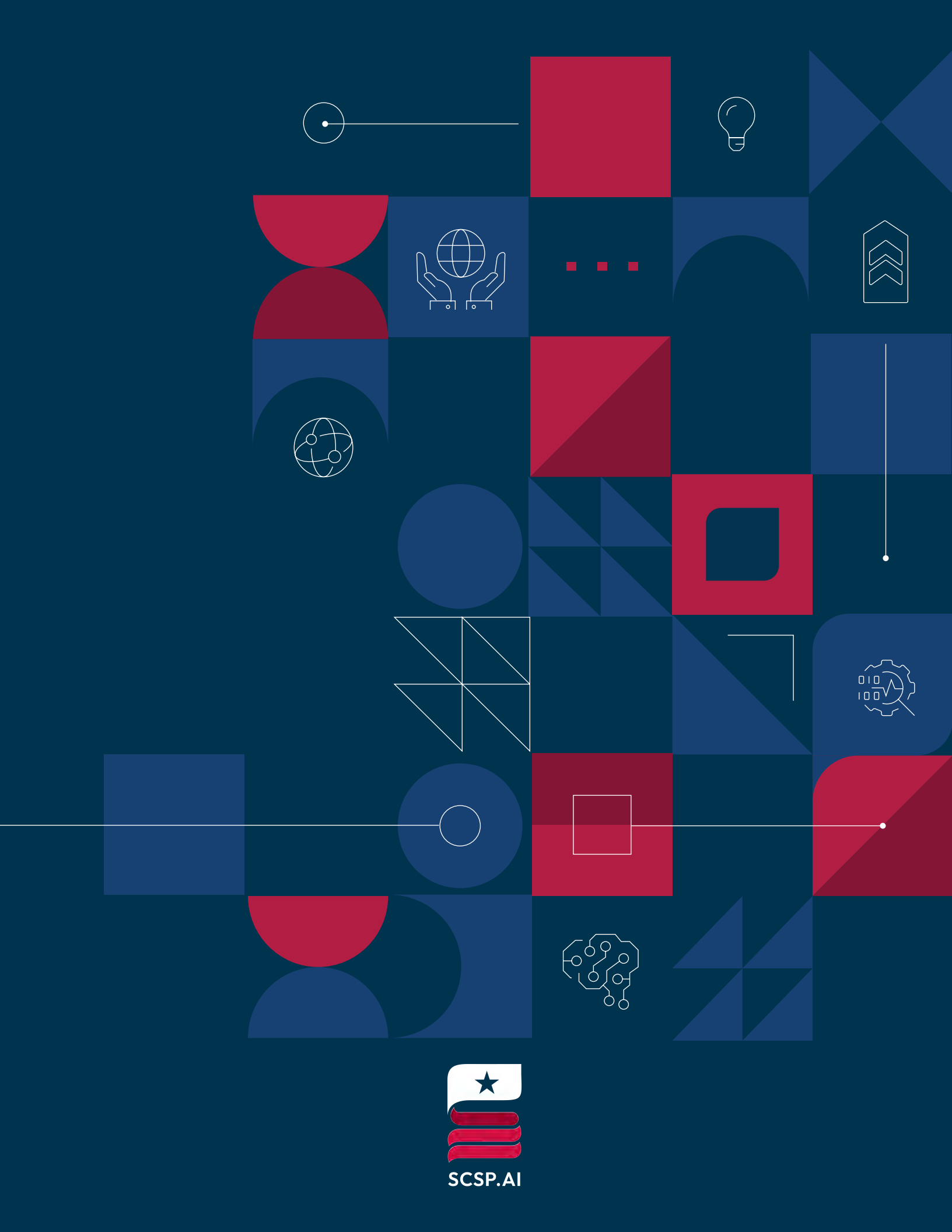
[370] The USG interagency has targeted PRC firms through a variety of policy vehicles including Executive Orders, the Department of Commerce Entity List, CFIUS actions, FCC license revocations, federal procurement bans, State Department visa restrictions, Department of Justice indictments, Department of Treasury investment bans (e.g., the Non-SDN Chinese Military-Industrial Complex Companies List), and others.
[371] Entity List, Supplement No. 4 to Part 744, Bureau of Industry and Security (2022). For FDPR entities, see 87 Fed. R. 62186, Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification, U.S. Department of Commerce, Bureau of Industry and Security (2022).
[372] John McCormick, et al., Huawei, Ericsson or Nokia? Apple or Samsung? U.S. or China? Who's Winning the 5G Races, Wall Street Journal (2021).
[373] Karen Freifeld & Alexandra Alper, Huawei, SMIC Suppliers Received Billions Worth of Licenses for US Goods, Reuters (2021).

U.S. investors in PRC firms may still be unwittingly supporting PRC military technology development in spite of the Department of Treasury Non-SDN Chinese Military-Industrial Complex Companies List, which bars U.S. investments in firms connected to the PRC military. For example, as of 2020, e-commerce giant **Alibaba** – which is listed on the U.S. stock exchange – was involved in a joint venture with PRC defense conglomerate **NORINCO** focused on satellite technology called **Qianxun Spatial Intelligence**.[374]	**Transparency, Delistings, and Divestitures:** More should be done to shine light on the complex web of corporate ownership structures inside of the PRC to determine military affiliation. PRC firms listed in the United States should be required to delist or divest if they have ties to the PRC military and U.S. regulators should work to ensure that American capital does not support the firms.[375]
Hikvision – one of the world's largest security camera manufacturers, based in China – was listed on the EL in 2019 for aiding in the targeting of ethnic Uyghurs in Western China[376] – but it continues to freely sell its products around the world, including in the U.S. market. U.S. policy as it stands today prohibits U.S. suppliers from selling components to Hikvision, but Hikvision can still freely sell its products to U.S. consumers.	**Sanctions: Adding Hikvision to the Specially Designated Nationals (SDN) list**[377] for its human rights abuses would dramatically undercut the firm's ability to do business and prohibit U.S. firms and citizens from carrying out transactions with the firm.
PRC state-owned enterprise **Nuctech**, the world's leading company by revenue for cargo and vehicle scanners used at ports and airports, was banned from U.S. airports in 2014 due to security concerns.[378] In 2020, Nuctech was added to the EL because its equipment performed below par at detecting radioactive materials[379] – raising the risk of WMD proliferation. Nuctech continues to expand in other countries that have no such restrictions in place. It has secured contracts in 26 out of 27 EU member states, including in gateways to the United States, NATO members' borders with Russia, and Europe's largest ports.[380]	**Diplomatic outreach:** The United States should urge allies and partners to bar the use of Nuctech equipment in border locations.

[374] Luz Ding, Is Alibaba-backed navigation service Qianxun at risk of U.S. sanctions?, The China Project (2020).
[375] Kiuyan Wong & Lulu Yilun Chen, US-China Audit Deal Faces First Test as Inspectors Head to Hong Kong, Bloomberg (2022).
[376] US Names Hikvision, Chinese Security Bureaus to Economic Blacklist, CNBC (2019).
[377] As of May 2022, the Biden Administration was considering adding Hikvision to the SDN list, but efforts appear to have stalled. See Demetri Sevastopulo, US Moves Towards Imposing Sanctions on Chinese Tech Group Hikvision, Financial Times (2022).
[378] Rohan Abraham, US Accuses Chinese Screening Tech Firm Nuctech of Passing Passenger Info to Beijing, The Economic Times (2020). For more on how Nuctech copied European technology and rose to become a national security threat across Europe, see William C. Hannas & Didi Kirsten Tatlow, China's Quest for Foreign Technology: Beyond Espionage, Routledge at 211-216 (2021).
[379] 85 Fed. R. 83416 Addition of Entities to the Entity List, Revision of Entry on the Entity List, and Removal of Entities From the Entity List, U.S. Department of Commerce, Bureau of Industry and Security (2020).
[380] Erika Kinetz, Security Scanners Across Europe Tied to China Government, Military, Associated Press (2022).

Two subsidiaries of **BGI,** a PRC-based genomics company with close ties to Beijing, were added to the EL in 2020 for supporting PRC repressive policies targeting ethnic minorities in Xinjiang.[381] Despite these concerns, in August 2022, another BGI subsidiary got the green light to sell its sequencers in the United States. In October 2022, DOD added BGI to its list of PRC military companies operating in the United States.[382]	**Investment and export restrictions:** CFIUS should screen and restrict BGI's efforts to expand market share in the United States. BGI should be placed on Treasury's Non-SDN Chinese Military-Industrial Complex Companies List, barring U.S. investment in the firm.[383] Additional BGI subsidiaries, and the parent company, should be added to the EL, which would require U.S. exporters to obtain a license to export to the firm. Federal research funding should be banned from supporting BGI.[384]

[381] Beijing Liuhe BGI and Xinjiang Silk Road BGI were placed on the BIS Entity in 2020 for "enabling activities contrary to the foreign policy interests of the United States through conducting genetic analyses used to further the repression of Muslim minority groups in the XUAR". See 85 Fed. R. 44159, Addition of Certain Entities to the Entity List; Revision of Existing Entries on the Entity List, U.S. Department of Commerce, Bureau of Industry and Security (2020).
[382] For the DoD list of specific PRC firms (including BGI) with clear ties to MCF, see DOD Releases List of People's Republic of China (PRC) Military Companies in Accordance With Section 1260H of the National Defense Authorization Act for Fiscal Year 2021, U.S. Department of Defense (2022). For BGI subsidiaries placed on Entity List, see "BGI" entry in Mapping China's Tech Giants, Australian Strategic Policy Institute (last accessed 2022). For more on BGI's links to the surveillance state in Xinjiang, see Zachary Basu, U.S. Blacklists Chinese Companies Tied to Xinjiang Gene Bank Project, Axios (2020). U.S. collaboration with China on biotechnology has contributed to Beijing's genomic surveillance in Xinjiang. See Sui-Lee Wee, China Uses DNA to Track Its People, with with the Help of American Expertise, New York Times (2019).
[383] Non-SDN Chinese Military-Industrial Complex Companies List, U.S. Department of Treasury (2021).
[384] For more on federally-funded research collaboration (i.e. National Institute of Health) with BGI, see Threats to the U.S. Research Enterprise: China's Talent Recruitment Plans, Permanent Subcommittee on Investigations, U.S. Senate at 57-58 (2019).



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