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Research Collaboration in an Era of Strategic Competition

AUTHORS

Stephanie Segal
Dylan Gerstel

A Report of the CSIS SIMON CHAIR IN POLITICAL ECONOMY

CSIS

CENTER FOR STRATEGIC &
INTERNATIONAL STUDIES

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Center for Strategic & International Studies
1616 Rhode Island Avenue, NW
Washington, D.C. 20036
202-887-0200 | www.csis.org

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1. CSIS, “Collateral Damage? Research Collaboration in an Age of U.S.-China Competition, CSIS event, June 4, 2019, <https://www.csis.org/events/collateral-damage-research-collaboration-age-us-china-competition>.

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Executive Summary

Forty years ago, Presidents Jimmy Carter and Deng Xiaoping signed the first U.S.-China Agreement on Cooperation in Science and Technology (S&T). The agreement promoted scientific exchange between the two countries and ushered in an era of robust bilateral research cooperation.² Today, however, there is a growing concern in Washington that certain aspects of S&T collaboration pose a risk to economic and national security, making it the latest front in rising U.S.-China competition.

Although Washington had similar concerns with technology “leakage” to the Soviet Union during the Cold War, the risks posed by China today are different in scope and sophistication. Top U.S. intelligence officials have recently characterized Chinese graduate students and researchers at U.S. universities and laboratories as part of Beijing’s “societal approach to stealing innovation.”³ In response, lawmakers and administration officials have proposed stricter controls on foreign citizens’ access to U.S. scientific research, including by implementing stricter visa requirements and restricting participation in research at universities, national laboratories, and private companies.

At the same time, the U.S. innovation ecosystem depends greatly on foreign researchers and partnerships with foreign research institutions. As stated in National Security Decision Directive 189 (NSDD-189), “The strength of American science requires a research environment conducive to creativity, an environment in which the free exchange of ideas is a vital component.”⁴ In the words of Massachusetts Institute of Technology (MIT) President L. Rafael Reif, “If all we do in response to China’s ambition is to try to double-lock all our doors, I believe we will lock ourselves into mediocrity.”⁵

These considerations underscore the importance of a well-calibrated strategy toward foreign research collaboration that maximizes openness while protecting intellectual property (IP), research integrity, and national security. U.S. government agencies should

2. U.S. Office of Science and Technology Cooperation, *United States-China Science and Technology Cooperation* (Washington, DC: Department of State, December 2006), <https://2001-2009.state.gov/documents/organization/96437.pdf>.

3. “A Conversation With Christopher Wray,” Council on Foreign Relations, April 26, 2019, <https://www.cfr.org/event/conversation-christopher-wray-0>.

4. “National Policy on the Transfer of Scientific, Technical, and Engineering Information,” Federation of American Scientists, September 21, 1985, <https://fas.org/irp/offdocs/nsdd/nsdd-189.htm>.

5. L. Rafael Reif, “China’s Challenge Is America’s Opportunity,” *New York Times*, August 8, 2018, <https://www.nytimes.com/2018/08/08/opinion/china-technology-trade-united-states.html>.

work with universities and national laboratories to: enforce existing IP protections; disseminate and enforce conflict of interest and conflict of commitment disclosure requirements; and ensure adherence to peer review standards, including confidentiality. These efforts should preserve the ability of the United States to attract top talent, including by maintaining a welcoming environment for foreign researchers. Collaborating widely with international scientists is necessary to expose U.S. researchers to the best global talent and research, recognizing that the United States is not the undisputed global leader in all research fields. Mindful of the realities of global competition, any policy responses should consider the policies and approaches of third countries and coordinate actions with U.S. allies and partners.

Finally, the United States can only remain a global science and technology leader by investing at home. To boost human capital, efforts should focus on improving science, technology, engineering, and math (STEM) outcomes, attracting and retaining more women and minorities in STEM fields, and expanding pathways for foreign students to remain in the United States after completing their degrees without reliance on funding sources of concern.

An Old Issue in a New Era

Concerns about potential national security risks stemming from collaboration with foreign researchers are not new. For decades, going back to the Cold War, U.S. policymakers have tried to balance science and security—maintaining an open, collaborative research ecosystem while safeguarding against espionage threats. However, China’s size, global integration, and innovation prowess present new challenges for policymakers.

During the Reagan administration, the Department of Defense (DOD) and National Science Foundation (NSF) commissioned a report examining controls on access to scientific information amid concerns that the Soviet Union had “gained militarily from access to the results of U.S. scientific and technological efforts.”⁶ The resulting *1982 Scientific Communication and National Security Report* recommended dividing university research into three categories: (1) activities where the benefits of total openness overshadow the costs of restrictions (the majority of research); (2) activities where classification is clearly necessary (research that “demonstrably will lead to military products in a short time”); and (3) a “small gray area” of dual-use (military and civilian) technologies where limited restrictions short of classification are appropriate, such as deemed export licenses when foreign researchers are involved.⁷

NSDD-189, issued in 1985, codified these recommendations and established national policy for controlling the flow of science, technology, and engineering information produced in federally-funded fundamental research at universities and national laboratories. The directive affirmed the Reagan administration’s policy of keeping fundamental research, which is published and publicly shared, unrestricted “to the maximum extent possible.” The administrations of Presidents George W. Bush and Barack Obama endorsed this approach,^{8,9} and last year the National Science Board stated that it “strongly reaffirms the principle behind President Reagan’s NSDD-189.”¹⁰

6. Institute of Medicine, National Academy of Sciences, and National Academy of Engineering, *Scientific Communication and National Security* (Washington, DC: National Academies Press, 1982), 1-5, <https://www.nap.edu/catalog/253/scientific-communication-and-national-security>.

7. Ibid.

8. Condoleezza Rice, “Letter on NSDD-189,” Association of American Universities, November 1, 2001, <https://www.aau.edu/key-issues/condoleezza-rice-letter-nsdd-189>.

9. Ashton Carter, John Young, and The White House, “Memoranda of the Military Departments & National Policy on the Transfer of Scientific, Technical, and Engineering Information,” Department of Defense, <https://fas.org/irp/doddir/dod/research.pdf>.

10. “Statement of the National Science Board on Security and Science,” National Science Board, October 24, 2018,

Yet, this approach sits uncomfortably alongside growing U.S.-China military and economic competition. The intelligence community fears China is exploiting the open U.S. research environment by “stealing innovation in any way it can,” including through researchers working on behalf of the Chinese government.¹¹ In addition, science and technology have evolved such that the “small gray area” of dual-use (military and civilian) technologies has expanded to encompass much of leading scientific research.

These assessments have led to a re-evaluation of policy toward foreign research collaboration as part of a broader effort to identify threats to U.S. economic competitiveness and to limit leakage of “critical technologies” to China.¹² U.S. government agencies have taken various measures to increase scrutiny of foreign researchers over the past year, while lawmakers have introduced legislation that would result in stricter controls on certain foreign students’ access to “sensitive research.”^{13,14} Officials argue that tighter controls are necessary to combat Chinese economic espionage and technology theft, but academics and businesses warn that such controls could undermine U.S. innovation leadership and stymie scientific progress.

https://www.nsf.gov/news/news_summ.jsp?cntn_id=297039.

11. “A Conversation With Christopher Wray,” Council on Foreign Relations.

12. Last year, President Trump signed the Foreign Investment Risk Review Modernization Act (FIRRMA), which expands CFIUS’s jurisdiction to include certain non-controlling investments by foreign persons in certain U.S. businesses that produce, design, test, manufacture, fabricate, or develop a critical technology. and the Export Control Reform Act (ECRA), which establishes a new category of export controls on “emerging” and “foundational” technologies.

13. U.S. Congress, House, *Protect Our Universities Act of 2019*, HR 1678, 116th Cong., 1st sess., March 12, 2019, <https://www.congress.gov/bill/116th-congress/house-bill/1678/text>.

14. For example, the People’s Republic of China, the Democratic People’s Republic of Korea, the Russian Federation, and the Islamic Republic of Iran.

China's Strategy to Become an Innovation Leader

Over the past decade, Beijing has prioritized transforming China from the world's factory to a leading innovation and technological power, with President Xi calling innovation “the primary driving force behind development” and “the strategic underpinning for building a modernized economy.”¹⁵ To achieve its goal, China has invested heavily in research and development (R&D), building human capital, and furthering its integration into international scientific communities.

Increased R&D funding has been foundational to China's technological development. According to the Organization for Economic Co-operation and Development (OECD), China's R&D expenditure as a percent of its GDP has increased from 0.7 percent (\$2.8 billion) in 1991 to 2.2 percent (\$263 billion) in 2017.¹⁶ Over the same period, U.S. R&D spending increased from 2.6 percent (\$161 billion) to 2.8 percent (\$542 billion) of GDP, roughly the same level as a percent of GDP as the 1960s.^{17,18} The United States still maintains a sizeable advantage in basic research, which the OECD defines as “experimental or theoretical work undertaken primarily to acquire new knowledge” without a specific short-term commercial application.¹⁹ U.S. expenditure on basic R&D was 0.5 percent of GDP in 2017, while Chinese expenditure was 0.1 percent of GDP.²⁰ However, U.S. federally-funded R&D spending, the largest source of basic research funding, has declined from 1.6 percent of GDP in 1960 to 0.6 percent of GDP in 2017.^{21,22}

15. Xi Jinping, “Full text of Xi Jinping's report at 19th CPC National Congress,” *China Daily*, November 4, 2017, http://www.chinadaily.com.cn/china/19thcpcnationalcongress/2017-11/04/content_34115212.htm.

16. “Main Science and Technology Indicators,” OECD, August 1, 2019, <https://www.oecd.org/sti/msti.htm>.

17. “National Patterns of R&D Resources: 2016-2017 Update,” National Science Foundation, February 27, 2019, <https://ncses.nsf.gov/pubs/nsf19309/#&>.

18. “Science & Engineering Indicators 2018 Chapter 4 Statistical Tables,” National Science Board, https://www.nsf.gov/statistics/2018/nsb20181/assets/1038/research-and-development-u-s-trends-and-international-comparisons_atables.pdf.

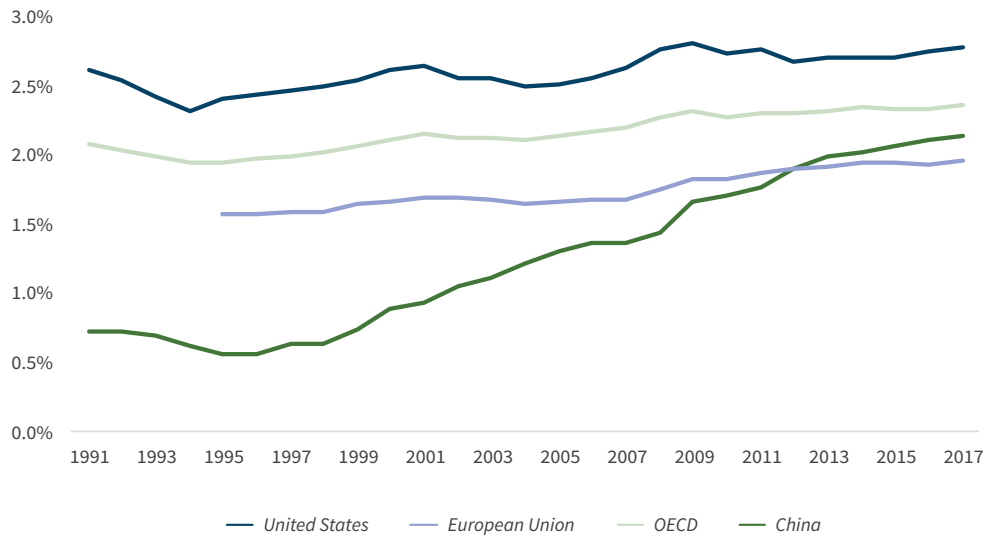
19. “Frascati Manual 2015 Glossary of Terms,” OECD, 2015, <http://www.oecd.org/sti/inno/Frascati-2015-Glossary.pdf>.

20. “Main Science and Technology Indicators,” OECD.

21. According to the NSF, in 2015 federal agencies provided 44 percent of total basic research funding, down from 61 percent in 2004. The private sector provided 27 percent of basic R&D spending in 2015.

22. “National Patterns of R&D Resources: 2016-2017 Update,” National Science Foundation.

GROSS DOMESTIC EXPENDITURE ON R&D (PERCENT OF GDP)



Source: OECD, "Main Science and Technology Indicators."

Alongside increased R&D funding, China has boosted efforts to train researchers at home and abroad in STEM fields. Of the over 7.4 million students who obtain a bachelor's degree in China every year, 35 percent concentrate in S&T, compared with only 18 percent of undergraduates in the United States.^{23,24} In 2016, China conferred 2.5 million undergraduate degrees in STEM fields as compared with an estimated 700,000 in the United States.^{25,26,27} In terms of doctoral degrees, the United States produced 32,359 PhD recipients in STEM fields in 2017 as compared with 32,700 in China.^{28,29} Over one-third of U.S. STEM PhD recipients are temporary visa holders, underscoring the U.S. reliance on foreign students for S&T research.³⁰

23. "Number of Undergraduate Students by Type of Courses in Regular HEIs," Ministry of Education of the People's Republic of China, 2017, http://en.moe.gov.cn/Resources/Statistics/edu_stat2017/national/201808/t20180808_344677.html.

24. "Status and Trends in the Education of Racial and Ethnic Groups, Indicator 26: STEM Degrees," National Center for Education Statistics, https://nces.ed.gov/programs/raceindicators/indicator_REG.asp.

25. "Number of Undergraduate Students by Type of Courses in Regular HEIs," Ministry of Education of the People's Republic of China, 2017, http://en.moe.gov.cn/Resources/Statistics/edu_stat2017/national/201808/t20180808_344677.html.

26. "Education Statistics: US STEM," World Bank, 2017, <https://databank.worldbank.org/US-STEM-%28ISCED-and-Tertiary%29/id/cd77ac48>.

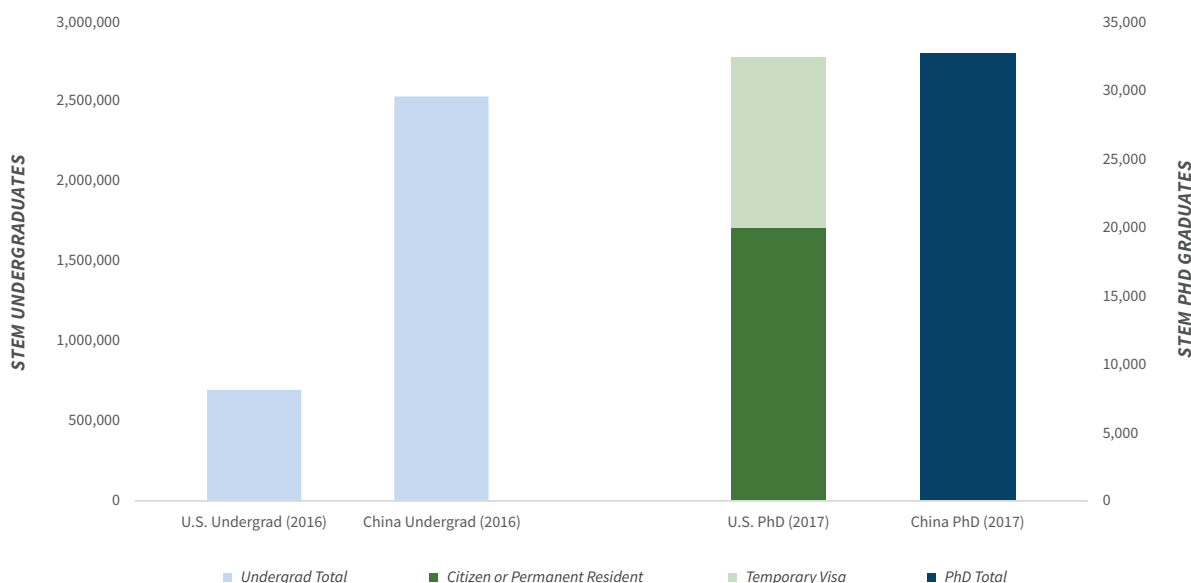
27. China's Ministry of Education classifies graduates using a "Natural Sciences and Technology" category rather than a STEM label. The Chinese "Science and Technology" and U.S. "STEM" classifications are similar, although the comparison is imperfect. For both the United States and China, these figures include all undergraduate degrees, including bachelor's and associate's for the United States and normal and short-term courses for China.

28. Chinese PhD-level data includes all doctorate graduates in the "Science" and "Engineering" categories. The United States STEM PhD data includes the following degree categories: life sciences, physical and earth sciences, mathematics and computer sciences, and engineering.

29. "Number of Postgraduate Students by Academic Field (Total)," Ministry of Education of the People's Republic of China, 2017, http://en.moe.gov.cn/Resources/Statistics/edu_stat2017/national/201808/t20180808_344681.html.

30. Kelly Kang, "Data Tables: Doctorate Recipients from U.S. Universities: 2017," National Science Foundation, <https://nces.nsf.gov/pubs/nsf19301/data>.

NUMBER OF STEM GRADUATES IN UNITED STATES AND CHINA



Sources: National Center for Education Statistics, "Status and Trends in the Education of Racial and Ethnic Groups, Indicator 26: STEM Degrees"; Ministry of Education of the People's Republic of China, "Number of Undergraduate Students by Type of Courses in Regular HEIs"; Ministry of Education of the People's Republic of China, "Number of Postgraduate Students by Academic Field (Total)."

Today, China is the largest source of foreign students in the United States, and the United States is the primary destination for Chinese students studying abroad. China accounts for one-third of all international students in the United States, sending more than twice as many students as India, the next largest source.³¹ The Institution of International Education, a non-profit organization supported by the U.S. government, estimates that 363,341 Chinese citizens were enrolled in U.S. higher education institutions in the 2017-18 academic year, including 130,843 at the graduate level.³² This is a nearly seven-fold increase from 1999-2000, when China sent 54,466 students.³³ In 2017, 93 percent of Chinese doctoral students in the United States concentrated in science and engineering, accounting for 16 percent of all U.S. STEM PhD recipients.³⁴

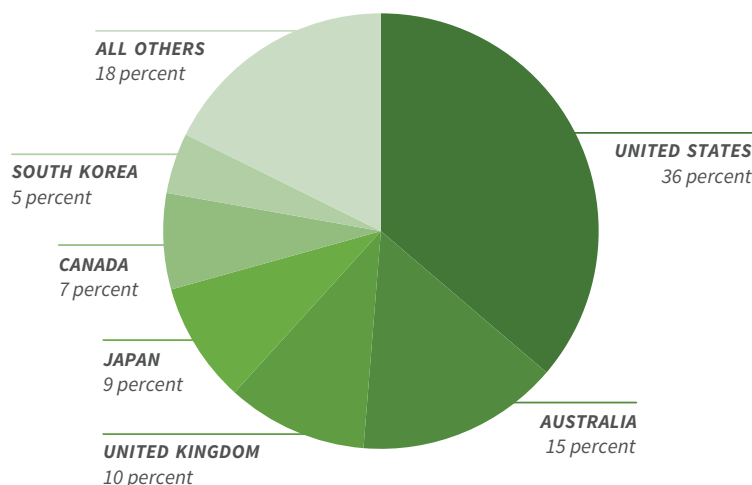
31. "Global Flow of Tertiary-Level Students," UNESCO Center for Statistics, 2019, <http://uis.unesco.org/en/uis-student-flow#slideoutmenu>.

32. "Place of Origin," Institute of International Education, 2019, <https://www.iie.org/Research-and-Insights/Open-Doors/Data/International-Students/Places-of-Origin>.

33. "Leading Places of Origin: Previous Years," Institute of International Education, 2019, <https://www.iie.org/Research-and-Insights/Open-Doors/Data/International-Students/Places-of-Origin/Leading-Places-of-Origin/2000-01>.

34. Kang, "Data Tables: Doctorate Recipients from U.S. Universities."

DESTINATIONS FOR CHINESE STUDENTS STUDYING ABROAD



Source: UNESCO Center for Statistics, "Global Flow of Tertiary-Level Students."

Many foreign doctorate students choose to remain in the United States after graduation and add to the most highly trained segment of the global science and engineering (S&E) workforce. According to NSF data, the "stay rate"—reflecting intentions to stay in the United States after receiving a doctorate—averaged 71.5 percent for all doctorate recipients with temporary visas from 2011-2017.³⁵ Doctorate recipients from China averaged a stay rate of 81.9 percent, with the most recent data (2017) showing a slight increase over this period.³⁶

Notwithstanding the historically high stay rates of Chinese doctoral recipients, Beijing has intensified efforts to lure back Chinese academics and attract leading foreign (non-Chinese national) researchers. The central government's flagship Thousand Talents Program, for example, specifically targets S&T experts by reducing administrative barriers for researchers moving to China and offering incentives, including an initial starting bonus with relocation compensation, housing and meal allowances, health insurance, and support for spouses and children.^{37,38} Most importantly, these programs offer larger funding opportunities for research with higher acceptance rates of grant proposals than most U.S. programs. Chinese state-run media claim that the Thousand Talents Program has recruited more than 40,000 people to China since its inception.³⁹ Other Chinese subnational programs, such as those in Shenzhen and Hangzhou, complement national efforts and direct researchers to specific projects.⁴⁰

35. Ibid.

36. Of the more than 40 nationalities included in the NSF survey, seven registered average stay rates of 80 percent or more: Venezuela (80.2), Nigeria (81.1), China (81.9), India (85.8), Bangladesh (86.4), Nepal (88.2), and Iran (90.1).

37. "The Thousand Talents Plan: The Recruitment Program for Innovative Talents (Long Term)," Recruitment Program of Global Experts, <http://www.1000plan.org.cn/en/>.

38. U.S.-China Economic and Security Review Commission, *2017 Report to Congress* (Washington, DC: November 2017), https://www.uscc.gov/sites/default/files/annual_reports/2017_Annual_Report_to_Congress.pdf.

39. Su Zhou, "Returnees finding big opportunities," *China Daily*, February 25, 2017, http://www.chinadaily.com.cn/china/2017-02/25/content_28345785.htm.

40. Louis Lucas and Emily Fung, "China's push to become a tech superpower triggers alarms abroad," *Financial*

China's investments in R&D and human capital have been accompanied by an unprecedented integration of the U.S. and Chinese research communities. When the first bilateral Agreement on Cooperation in Science and Technology was signed in 1979, there were three papers jointly authored by U.S. and Chinese scientists; by 2012, that number had increased to 20,371.⁴¹ According to the National Science Board's (NSB) *Science and Engineering Indicators 2018*, almost half (46.1 percent) of China's internationally coauthored publications had a U.S. coauthor in 2016, while China accounted for 22.9 percent of U.S. internationally coauthored publications, followed by the United Kingdom (13.4 percent), Germany (11.2 percent), and Canada (10.2 percent).⁴² The increased collaboration between the United States and China is consistent with a general trend toward greater cross-border collaboration in science globally; however, the data also show a heavier reliance on bilateral collaboration with one another than with any other single country.

Several factors account for the high degree of integration between Chinese and U.S. scientific communities. U.S. and Chinese universities are consistently ranked among the top universities globally, including in fields such as engineering and computer science, which play prominently into China's innovation goals.⁴³ There is also the sheer size of China's population, and its focus on STEM education, which produces a supply of qualified researchers that effectively compensate for the dearth of U.S. STEM graduates.

Notwithstanding productive collaboration to date between U.S. and Chinese scientific communities, U.S. government funding agencies, law enforcement, and academic institutions have also uncovered behavior that is challenging the relationship. There are reported cases of unethical or even illegal activities, including Chinese researchers hiding ties to the Chinese government, violating the peer review process, or even stealing IP outright.^{44,45,46} The challenge facing U.S. universities, as well as policymakers, is two-fold: first, how to identify activity that violates legal or research and ethical standards, particularly when violations threaten national security; and second, how to address these risks while maintaining U.S. global innovation leadership, the openness of the scientific enterprise, and the attractiveness of the United States as a destination for foreign researchers.

Times, March 19, 2017, <https://www.ft.com/content/1d815944-f1da-11e6-8758-6876151821a6>.

41. Caroline S. Wagner, Lutz Bornmann, and Loet Leydesdorff, "Recent Developments in China-U.S. Cooperation in Science," *Minerva* 53, no.3 (September 2015), <https://arxiv.org/ftp/arxiv/papers/1404/1404.6545.pdf>.

42. National Science Board, "Chapter 5: Academic Research and Development," in *Science and Engineering Indicators 2018* (Alexandria, VA: 2018), <https://nsf.gov/statistics/2018/nsb20181/assets/968/academic-research-and-development.pdf>.

43. "U.S. News Unveils 2019 Best Global Universities Rankings," *U.S. News and World Report*, October 230, 2018, <https://www.usnews.com/info/blogs/press-room/articles/2018-10-30/us-news-unveils-2019-best-global-universities-rankings>.

44. Tara Law, "Emory University Fires 2 Neuroscientists Accused of Hiding Chinese Ties," *Time*, May 25, 2019, <https://time.com/5596066/emory-fires-chinese-researchers/>.

45. Mara Hvistendahl, "Major U.S. cancer center ousts 'Asian' researchers after NIH flags their foreign ties," *Science Magazine*, April 19, 2019, <https://www.sciencemag.org/news/2019/04/exclusive-major-us-cancer-center-ousts-asian-researchers-after-nih-flags-their-foreign>.

46. Molly Jones and Raija Horstman, "Criminal Prosecution of Chinese Trade Secret Misappropriation," *Crowell Morning Trade Secrets Trends*, July 24, 2019, <https://www.crowelltradesecretstrends.com/2019/07/criminal-prosecution-of-chinese-trade-secret-misappropriation/>.

WHO LEADS?

Protecting sensitive areas of research requires an accurate assessment of the competitive landscape. A 2019 Information Technology & Innovation Foundation report found that while China still lags in “first-to-the-world” science- and engineering-based innovation, it is catching up, and an evaluation of China’s high-tech development by the U.S.-China Commission (USCC) shows China gaining ground across all high-tech sectors.^{47,48} Many areas have dual-use applications, fueling fears that the U.S. military will lose its qualitative technological edge if China develops these technologies first.

Artificial Intelligence (AI): China has plans to become the global AI leader by 2030.⁴⁹ With 20 percent of the world’s data—expected to increase to 30 percent by 2030—China has a key structural advantage over competitors.⁵⁰ The Allen Institute of AI found that China already publishes more AI papers than the United States and predicts that if trends continue China will overtake the U.S. share of the most-cited 10 percent of papers next year and the most-cited 1 percent of papers by 2025.⁵¹ However, while China is expanding its AI talent base, the United States remains the preferred destination for top researchers.⁵²

Quantum Information Science: Quantum supremacy is anticipated to convey both military and commercial advantage. China currently trails the United States in quantum research, but with aggressive state investments and accelerating patent filings, China could become the world’s quantum leader.⁵³

High-Performance Computing: The United States and China have been vying for supercomputing supremacy for more than a decade. Five of the world’s 10 fastest supercomputers are in the United States versus two in China; however, China previously claimed the fastest supercomputer (Tianhe-2), has more total supercomputers, and is on track to bring the world’s first exascale computer—capable of one quintillion calculations per second—online in 2020, ahead of expected U.S. and Japanese rollouts in 2021.⁵⁴

Biotechnology: According to the 2017 USCC annual report, U.S. biotechnology research and innovation remain ahead of China.⁵⁵ To close this gap, Beijing named

47. Robert Atkinson and Caleb Foote, “Is China Catching Up to the United States in Innovation?” Information Technology and Innovation Foundation, April 2019, <http://www2.itif.org/2019-china-catching-up-innovation.pdf>.

48. “Chapter 4: China’s High-Tech Development,” in U.S. Economic and Security Review Commission, *2017 Report to Congress*, https://www.uscc.gov/Annual_Reports/2017-annual-report.

49. Paul Mozur, “Beijing Wants A.I. to Be Made in China by 2030,” *New York Times*, July 20, 2017, <https://www.nytimes.com/2017/07/20/business/china-artificial-intelligence.html>.

50. Gregory Allen, “Understanding China’s AI Strategy,” Center for a New American Security, February 6, 2019, <https://www.cnas.org/publications/reports/understanding-chinas-ai-strategy>.

51. Carissa Schoenick, “China May Overtake U.S. in AI Research,” Allen Institute for Artificial Intelligence, March 13, 2019, <https://medium.com/ai2-blog/china-to-overtake-us-in-ai-research-8b6b1fe30595>.

52. Jay Dantong Ma, “China’s AI talent base is growing, and then leaving,” Macro Polo, July 30, 2019, <https://macropolo.org/chinas-ai-talent-base-is-growing-and-then-leaving/>.

53. Amit Katwala, “Why China’s perfectly placed to be quantum computing’s superpower,” *Wired*, November 14, 2018, <https://www.wired.co.uk/article/quantum-computing-china-us>.

54. Yoko Noge Dean, “US and China race to faster supercomputers amid simmering trade war,” *Nikkei Asian Review*, July 3, 2019, <https://asia.nikkei.com/Business/Technology/US-and-China-race-to-faster-supercomputers-amid-simmering-trade-war>.

55. “Annual Report Chapter 4: China’s High-Tech Development,” U.S. Economic and Security Review Commission.

biotechnology as a Strategic Emerging Industry and prioritized its development under Made in China 2025 and the 13th Five-Year Plan.

Robotics: The USCC report identified Japan and Germany as global leaders in industrial robotics and the United States as the leader in surgical robotics and collaborative robotics. China is rapidly expanding its capabilities, emerging as the world's largest robotics market. In 2016, China averaged 68 robots per 10,000 manufacturing employees, as compared with the global average of 74 and 189 in the United States.⁵⁶

Nanotechnology: Through the National Nanotechnology Initiative, U.S. government agencies have spent more than \$23 billion developing U.S. nanotechnology since 2001, establishing the United States as a global leader.⁵⁷ Although China trails in commercialization, it has become the fastest-growing country for nanotechnology publications.

Semiconductors: The U.S. semiconductor industry leads the world with nearly half of global market share and a dominant portion of R&D.⁵⁸ Currently, only 16 percent of semiconductors used in China are produced domestically, and only half of those are made by Chinese-owned firms, but China aims to produce 40 percent of the semiconductors it uses by 2020 and 70 percent by 2025.⁵⁹ One Chinese semiconductor research firm believes that China is still a “decade or two” away from closing the gap with the United States.⁶⁰

56. “Executive Summary World Robotics 2018 Industrial Robots,” International Federation of Robotics, 2018, https://ifr.org/downloads/press2018/Executive_Summary_WR_2018_Industrial_Robots.pdf.

57. National Science and Technology Council Committee on Technology Subcommittee on Nanoscale Science, Engineering, and Technology, *National Nanotechnology Initiative Strategic Plan* (Washington, DC: Executive Office of the President, October 2016), https://www.nano.gov/sites/default/files/pub_resource/2016-nni-strategic-plan.pdf.

58. “Proposed Determination of Action Pursuant to Section 301: China’s Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation,” Semiconductor Industry Association, July 20, 2018, https://www.semiconductors.org/wp-content/uploads/2018/08/Final-SIA_Submission_on_301_Tariffs.pdf.

59. James Lewis, *Learning the Superior Techniques of the Barbarians* (Washington, DC: CSIS, January 2019), https://csis-prod.s3.amazonaws.com/s3fs-public/publication/190115_Lewis_Semiconductor_v6.pdf.

60. Arjun Kharpal, “China is ramping up its own chip industry amid a brewing tech war. That could hurt U.S. firms,” CNBC, June 24, 2019, <https://www.cnbc.com/2019/06/04/china-ramps-up-own-semiconductor-industry-amid-the-trade-war.html>.

Risks of Research Collaboration

Washington has monitored potential national security risks from research collaboration with China since the beginning of bilateral scientific exchange. The *1982 Scientific Communication and National Security Report* predicted that vulnerabilities from scientific communication involving other countries “in time might overshadow the Soviet dimension.”⁶¹ The 1999 Cox Report, issued by a select congressional committee on U.S. national security concerns with China, warned Beijing was engaged in a wide-ranging campaign to obtain U.S. military technology.⁶² It identified the over 100,000 Chinese nationals studying in U.S. universities as “ready targets for (Chinese) intelligence officers.” During the 2000s, the Federal Bureau of Investigation (FBI) pursued several high-profile charges of “economic espionage” against Chinese scientists, including investigating a Duke University graduate for stealing technology and arresting a University of Wisconsin cancer scientist.^{63,64} Nonetheless, the vast majority of scientific collaboration was considered beneficial, and Washington and Beijing continued to promote two-way researcher exchange and collaboration.^{65,66}

This situation began to change during the second Obama administration, when concern for “leakage” of sensitive technologies led to a tightening of security protocols at U.S. National Laboratories. Concerns over China’s illicit access to U.S. intellectual property became more acute from the start of the Trump administration, leading to a reevaluation of research exchange with China. The 2017 U.S. National Security Strategy (NSS) concluded, “part of China’s military modernization and economic expansion is due to its access to the U.S. innovation economy, including America’s world-class universities.”⁶⁷

61. “Scientific Communication and National Security,” National Academy of Sciences, 1982, <https://www.nap.edu/catalog/253/scientific-communication-and-national-security>.

62. Select Committee, *U.S. National Security and Military/Commercial Concerns with The People’s Republic of China* (Washington, DC: May 25, 1999), <https://www.govinfo.gov/content/pkg/GPO-CRPT-105hrpt851/pdf/GPO-CRPT-105hrpt851.pdf>.

63. “University of Kansas Researcher Indicted for Fraud for Failing to Disclose Conflict of Interest with Chinese University,” Department of Justice, August 21, 2019, <https://www.justice.gov/opa/pr/university-kansas-researcher-indicted-fraud-failing-disclose-conflict-interest-chinese>.

64. Eliot Marshall, “Chinese Researcher in Wisconsin accused of Economic Espionage,” *Science Magazine*, April 2, 2013, <https://www.sciencemag.org/news/2013/04/chinese-researcher-wisconsin-accused-economic-espionage>.

65. Elizabeth Redden, “U.S., China Extend Terms for Student Visas,” *Inside Higher Ed*, November 13, 2014, <https://www.insidehighered.com/quicktakes/2014/11/13/us-china-extend-terms-student-visas>.

66. “Fact Sheet: U.S.-China Science and Technology Cooperation Highlights: 32 Years of Collaboration,” White House Archives, <https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/st-fact-sheet.pdf>.

67. “National Security Strategy of the United States of America,” White House, December 2017, <https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf>.

The NSS announced the United States' intention to "consider restrictions on foreign STEM students from designated countries to ensure that intellectual property is not transferred to our competitors, while acknowledging the importance of recruiting the most advanced technical workforce to the United States."

The U.S. intelligence community views Chinese students and researchers as potential tools in Beijing's arsenal to dominate future technologies. The FBI reports increased economic espionage activity related to China in nearly all of its 56 field offices.⁶⁸ In an April 2019 speech, FBI Director Christopher Wray said, "China has pioneered a societal approach to stealing innovation in any way it can from a wide array of businesses, universities, and organizations. They're doing it through Chinese intelligence services, through state-owned enterprises, through ostensibly private companies, through graduate students and researchers, through a variety of actors all working on behalf of China."⁶⁹ Senator Mark Warner (D-VA) echoed this assessment in a May 2019 speech, warning that China could access emerging technologies "through strategic collaboration with Western companies and universities."⁷⁰ Policymakers have also voiced concerns that American taxpayer dollars dedicated to research could unintentionally help China achieve technological supremacy.⁷¹

Part of the risk stems from researchers with direct ties to the Chinese military. A 2018 Australian Strategic Policy Institute report found the Chinese military had sponsored 2,500 scientists and engineers to study abroad since 2007, especially in the "Five-Eyes" countries of Australia, Canada, New Zealand, the United Kingdom, and the United States.⁷² In addition, Article 7 of China's 2017 National Intelligence Law stipulates, "any organization or citizen shall support, assist, and cooperate with state intelligence work," giving rise to broader concerns regarding virtually any type of collaboration.⁷³ The law's comprehensive nature has fueled concerns that Beijing could pressure average students and researchers into sharing sensitive information, even if they had no prior intention of doing so, making ordinary Chinese researchers both vulnerable and suspect.

Although existing research policies regulate transfer of IP and access to sensitive projects, government auditors have identified gaps in enforcement and compliance. For instance, a February 2019 Department of Health and Human Services Inspector General report warned that National Institutes of Health (NIH) officials had "not assessed the risks to national security when permitting data access to foreign principal investigators" working on genomic data.⁷⁴ The report recommended developing more stringent internal controls to verify compliance. Similarly, U.S. academic institutions have acknowledged the need to

68. "A Conversation With Christopher Wray," Council on Foreign Relations.

69. Ibid.

70. Mark Warner, "The China Challenge and Critical next steps for the United States," Brookings Institution, May 15, 2019, <https://www.brookings.edu/blog/order-from-chaos/2019/05/15/the-china-challenge-and-critical-next-steps-for-the-united-states/>.

71. U.S. Congress, Senate, Committee on Finance, *Foreign Threats to Taxpayer-Funded Research: Oversight Opportunities and Policy Solutions*, 116th Cong., 1st sess., June 5, 2019, <https://www.finance.senate.gov/hearings/foreign-threats-to-taxpayer-funded-research-oversight-opportunities-and-policy-solutions>.

72. Alex Joske, "Picking Flowers, Making Honey," Australian Strategic Policy Institute, October 30, 2018, <https://www.aspi.org.au/report/picking-flowers-making-honey>.

73. "2017 National Intelligence Law of the People's Republic," 2017 Chinese National People's Congress, June 27, 2017, http://cs.brown.edu/courses/csci1800/sources/2017_PRC_NationalIntelligenceLaw.pdf.

74. Gloria Jarmon, "Opportunities Exist for the National Institutes of Health to Strengthen Controls in Place to Permit and Monitor Access to Its Sensitive Data," Department of Health and Human Services Office of Inspector General, <https://oig.hhs.gov/oas/reports/region18/181809350.pdf>.

improve internal review and risk assessment processes, enforcement of conflict of interest and conflict of commitment disclosure requirements, and adherence to peer review standards, including confidentiality.

Recent U.S. Government Actions

Responding to these concerns, U.S. government agencies have taken various measures to increase scrutiny of foreign researchers. Although the intelligence community has taken the lead in briefing individual agencies, as well as academic and research communities, agency actions appear largely uncoordinated. Generally, these actions have focused on four areas: (1) improving the enforcement of existing institutional disclosure requirements; (2) preserving the confidentiality of the peer review; (3) enforcing IP protection; and (4) putting restrictions on U.S. government researchers affiliated with foreign recruitment programs.

In August 2018, NIH Director Francis Collins sent a letter to approximately 10,000 organizations applying for NIH funding to raise concerns about foreign influences on research integrity, including: (1) failure to disclose funding sources, including from foreign governments; (2) diversion of intellectual property from NIH-supported research, including to foreign countries; and (3) sharing of confidential information, including with foreign entities.^{75,76} As of May 2019, the NIH had directly contacted 61 institutions about these issues, leading to terminations of scientists who had violated NIH grant terms and conditions and a review of NIH-funded grants.⁷⁷ In April, MD Anderson Cancer Research Center dismissed three scientists after briefings from the NIH and FBI.⁷⁸ In May, Emory University fired two U.S.-government-funded scientists for allegedly failing to disclose foreign sources of funding and their research ties with China, charges the scientists dispute.^{79,80}

Other funding agencies have tightened their conflict of interest policies. In March, DOD announced enhanced disclosure requirements for key personnel working on DOD-

75. Francis Collins, “Statement on Protecting the Integrity of U.S. Biomedical Research,” NIH, August 23, 2018, <https://www.nih.gov/about-nih/who-we-are/nih-director/statements/statement-protecting-integrity-us-biomedical-research>.

76. Lawrence Tabak, “Testimony Before the Senate Committee on Finance,” Department of Health and Human Services, June 5, 2019, <https://www.finance.senate.gov/imo/media/doc/05JUN2019TabakSMNT.pdf>.

77. U.S. Congress, Senate, Committee on Finance, *Foreign Threats to Taxpayer-Funded Research*.

78. Todd Ackerman, “MD Anderson Ousts 3 Scientists Over Concerns about Chinese Conflicts of Interest,” *Houston Chronicle*, April 19, 2019, <https://www.houstonchronicle.com/news/houston-texas/houston/article/MD-Anderson-fires-3-scientists-over-concerns-13780570.php>.

79. Zhenhua Lu, “Emory University in U.S. fires scientists over undisclosed funding ties to China,” *South China Morning Post*, May 24, 2019, <https://www.scmp.com/news/china/diplomacy/article/3011732/us-emory-university-fires-scientists-over-undisclosed-funding>.

80. Jon Cohen, “Terminated Emory researcher disputes university’s allegations about China ties,” *Science Magazine*, May 24, 2019, <https://www.sciencemag.org/news/2019/05/terminated-emory-researcher-disputes-university-s-allegations>.

supported research, including listing all funding sources and other time commitments.⁸¹ On June 7, the Department of Energy issued a notice prohibiting employees and contractors from participating in foreign government talent recruitment programs sponsored by designated “countries of risk.”⁸²

In May 2019, the White House Office of Science and Technology Policy (OSTP) launched through the National Science and Technology Council the Joint Committee on Research Environments (JCORE) to bring a “whole of government” approach to address the most pressing challenges facing the U.S. research and scientific community.⁸³ Among JCORE’s four subcommittees, the Subcommittee on Research Security “aims to protect America’s researchers from undue foreign influence without compromising our values or our ability to maintain the openness and integrity of our innovation ecosystem.” As compared with individual agency efforts, JCORE’s efforts to standardize and align disclosure requirements across federal agencies could help address concerns of academia by reducing administrative burdens associated with ensuring research integrity.

CHINESE FOREIGN RECRUITMENT PROGRAMS

Over the past year, several U.S. government agencies have increased scrutiny of or banned researchers affiliated with Chinese foreign recruitment programs. For example, an April 2018 National Intelligence Council analysis said the Thousand Talents Program’s underlying goal was to “facilitate the legal and illicit transfer of U.S. technology, intellectual property, and know-how.”⁸⁴ In response, Beijing has quietly removed public references to researchers affiliated with the program and has limited program publicity on state-run websites.⁸⁵ Before the Thousand Talents website was scrubbed, it listed nearly 1,000 U.S. government and corporate experts who had accepted funding from the program.⁸⁶

81. Michael Griffin, “Actions for the Protection of Intellectual Property, Controlled Information, Key Personnel, and Critical Technologies,” Department of Defense, March 20, 2019, <https://www.aau.edu/sites/default/files/Blind-Links/OUSDRResearchProtectionMemo.pdf>.

82. “Department of Energy Foreign Government Talent Recruitment Programs,” Department of Energy, June 7, 2019, <https://www.directives.doe.gov/directives-documents/400-series/0486-1-border/@images/file>.

83. “Update from the National Science and Technology Council Joint Committee on Research Environments,” White House Office of Science and Technology Policy, July 9, 2019, <https://www.whitehouse.gov/wp-content/uploads/2019/07/Update-from-the-NSTC-Joint-Committee-on-Research-Environments-July-2019.pdf>.

84. Anthony Capaccio, “U.S. Faces ‘Unprecedented Threat’ from China on Tech Takeover,” Bloomberg, June 22, 2018, <https://www.bloomberg.com/news/articles/2018-06-22/china-s-thousand-talents-called-key-in-seizing-u-s-expertise>.

85. Smriti Mallapaty, “China hides identities of top scientific recruits amidst growing U.S. scrutiny,” *Nature*, October 24, 2018, <https://www.nature.com/articles/d41586-018-07167-6>.

86. Larry Diamond and Orville Schell, *China’s Influence and American Interests: Promoting Constructive Vigilance* (Washington, DC: Hoover Institution Press, 2019), https://www.hoover.org/sites/default/files/research/docs/00_diamond-schell-chinas-influence-and-american-interests.pdf.

CONGRESSIONAL ACTION AND PENDING LEGISLATION

Congress is also closely following the risks posed by foreign research collaboration. Section 1286 of last year's National Defense Authorization Act (2019 NDAA) instructs the secretary of defense to establish an initiative to work with relevant academic institutions to "limit undue influence, including through foreign talent programs, by countries to exploit United States technology within the DOD research, science and technology, and innovation enterprise." The act also requires the initiative to improve information sharing to enable awareness of security threats and capacity building, including with universities.⁸⁷ Over the past year, Congress has held several meetings on these issues, including a June 5 Senate Finance Committee hearing on "Foreign Threats to Taxpayer-Funded Research."^{88,89}

Members of Congress have introduced legislation that goes beyond actions taken by individual agencies. Notable bills include:

- The Securing American Science and Technology Act (SASTA), introduced by Representative Mikie Sherrill with bipartisan support, would establish an interagency working group under OSTP.⁹⁰ The working group would coordinate activities to protect federally-funded research from foreign theft or espionage; develop common definitions and best practices for federal grantees; and identify areas of research that might require future controls. It would also convene a roundtable to connect policymakers with university stakeholders.
- The Protect Our Universities Act of 2019, introduced by Senator Josh Hawley in the Senate and Representative Jim Banks in the House, would establish a U.S. Department of Homeland Security-led task force to maintain a list of "sensitive" research projects.⁹¹ Chinese, Iranian, or Russian citizens would have to pass a background check before participating in these projects.
- A Senate Armed Services Committee draft of the 2020 National Defense Authorization Act called for a list of Chinese institutions and companies with links to the Chinese military to be used for screening visa applications for students and researchers.⁹²

87. U.S. Congress, House, *John S. McCain National Defense Authorization Act for Fiscal Year 2019*, HR 2500, 115th Cong., 2nd sess., January 3, 2019, <https://www.congress.gov/115/bills/hr5515/BILLS-115hr5515enr.pdf>.

88. U.S. Congress, Senate, Committee on Finance, *Foreign Threats to Taxpayer-Funded Research*.

89. Ibid.

90. U.S. Congress, House, *Securing American Science and Technology Act of 2019*, HR 3038, 116th Cong., 2nd sess., May 30, 2019, <https://www.congress.gov/bill/116th-congress/house-bill/3038/text>.

91. U.S. Congress, Senate, *Protect Our Universities Act of 2019*, HR 1678, 116th Cong., 2nd sess., March 12, 2019, <https://www.congress.gov/bill/116th-congress/house-bill/1678>.

92. Mike Stone and Patricia Zengerle, "U.S. Senate committee unveils 2020 defense policy bill," Reuters, May 23, 2019, <https://www.reuters.com/article/usa-defense-spending/u-s-senate-committee-unveils-2020-defense-policy-bill-idUSL2N22Z096>.

Risks of Policy Overreach

While U.S. academic institutions and businesses share concerns over inaccurate disclosures and IP leakage, they worry that excessive restrictions on foreign research collaboration could jeopardize U.S. S&E leadership. Restricting collaboration—particularly in areas where other countries may be at the cutting-edge—may inadvertently limit access to advanced research, divert top talent to third countries, and fuel criticisms of racial profiling or xenophobia.

The United States is no longer the dominant player in global research that it once was. The U.S. share of global S&E research publications has declined from 24.4 percent in 2006 to 17.8 percent in 2016, while China's share has grown from 12.1 percent to 18.6 percent.⁹³ Over this time, cross-border research cooperation has grown. Globally, the percentage of S&E articles coauthored with international collaboration increased from 16.7 percent to 21.7 percent between 2006 and 2016, with the international collaboration rate reaching 37 percent for U.S. researchers, up from 25 percent in 2006.^{94,95} Excessive restrictions on international collaboration could limit U.S. scientists' access to and knowledge of cutting-edge research. Chinese scientists have warned that new U.S. research restrictions will hinder collaboration and threaten Chinese funding for joint projects.⁹⁶

Given the interdependence of the most advanced research, there is concern that excessive restrictions could divert top foreign talent away from the United States. Last June, the State Department issued guidance that Chinese graduate students in sensitive research areas could only apply for a one-year multiple-entry visa, rolling back an Obama-era policy allowing these students to apply for five-year multiple-entry visas.⁹⁷ This requires students to obtain a new visa if they travel outside the United States after a year and wish to return. The change in policy, along with the general chill in U.S.-China relations, appears to have

93. "Chapter 5: Academic Research and Development," in National Science Board, *Science and Engineering Indicators 2018*, <https://nsf.gov/statistics/2018/nsb20181/report/sections/academic-research-and-development/highlights#outputs-of-s-e-research-publications>.

94. National Science Board, *Science and Engineering Indicators 2018*.

95. Ibid.

96. Dennis Normile, "China's Scientists alarmed, bewildered by growing anti-Chinese sentiment in the United States," *Science Magazine*, July 31, 2019, <https://www.sciencemag.org/news/2019/07/china-s-scientists-alarmed-bewildered-growing-anti-chinese-sentiment-united-states>.

97. "Changes to visa length for some Chinese students," Boston University, June 11, 2018, <https://www.bu.edu/isso/2018/06/11/changes-to-visa-length-for-some-chinese-students/>; Jeffrey Mervis, "More restrictive U.S. policy on Chinese graduate student visas raises alarm," *Science*, June 11, 2018, <https://www.sciencemag.org/news/2018/06/more-restrictive-us-policy-chinese-graduate-student-visas-raises-alarm>.

pushed students away. In March, the number of Chinese students in the United States dropped by 2 percent compared to the previous year, the first drop since 2009. Other top destination countries for Chinese students, including the United Kingdom, Australia, and Canada, have seen an uptick in applications as a result.⁹⁸

Another potential downside of tighter control is the risk that scientists and engineers choose not to work on listed technologies or that some universities may view work on listed technologies as inconsistent with their “openness in research” policies or too administratively burdensome and expensive, depending on the direction of federal guidelines.

Finally, overly-restrictive or arbitrary policies based primarily on foreign nationality stoke fears of xenophobia and racial profiling. There have been several reported cases of the FBI arresting Chinese scientists on espionage charges, only to drop them months later.⁹⁹ Representative Judy Chu, chair of the Congressional Asian Pacific American Caucus, has said inflammatory FBI rhetoric causes anxiety in the Chinese-American community and raises the risk of “an erosion of Chinese Americans’ civil rights.” Several top U.S. universities, including Yale, Columbia, and Stanford, have reaffirmed their support for Chinese students, and on June 25, MIT President L. Rafael Reif sent a campus-wide letter urging the community “not to create a toxic atmosphere of unfounded suspicion and fear” for Chinese researchers.^{100,101}

98. Poormina Weerasekara, “Put off by U.S., Chinese students eye other universities,” Yahoo News, July 7, 2019, <https://news.yahoo.com/put-off-us-chinese-students-eye-other-universities-033810321.html>.

99. Peter Waldman, “The U.S. is purging Chinese cancer researchers from top institutions,” Bloomberg, June 13, 2019, <https://www.bloomberg.com/news/features/2019-06-13/the-u-s-is-purging-chinese-americans-from-top-cancer-research>.

100. Jodi Xu Klein, “U.S. academics condemn ‘racial profiling’ of Chinese students and scholars over spying fears,” *South China Morning Post*, <https://www.scmp.com/news/china/diplomacy/article/3022413/us-academics-condemn-racial-profiling-chinese-students-and>.

101. L. Rafael Reif, “Immigration is a Kind of Oxygen,” MIT News, June 25, 2019, <http://news.mit.edu/2019/letter-community-immigration-is-oxygen-0625>.

Beyond Bilateral Competition

While many U.S. allies and partner countries share similar concerns with China's industrial policies and IP theft, none thus far have responded as aggressively as the United States, including in the area of research collaboration. Some countries are also skeptical of U.S. motivations, believing actions toward China, including in the area of research collaboration, are aimed at protecting technological U.S. leadership rather than specific national security concerns.

Many U.S. allies, especially European countries, have deep education and research ties with China. Nearly 170,000 Chinese students were enrolled in tertiary education in the European Union in 2016, about half the number studying in the United States.¹⁰² Hundreds of university exchange partnerships across Europe facilitate and deepen this exchange.¹⁰³ Similarly, China is on track to replace the United States as Australia's largest international collaborator on scientific research papers this year.¹⁰⁴

In addition, over the last 15 years, the number of foreign-owned R&D centers in China has increased from 200 to over 1,500, including a large number of American, Japanese, and Korean companies.¹⁰⁵ As U.S.-China tensions have escalated, major European companies, including Siemens, Merck, and Daimler, announced new R&D facilities in China in the past year.^{106,107,108}

102. "Learning Mobility Statistics," Eurostat, September 2018, https://ec.europa.eu/eurostat/statistics-explained/index.php/Learning_mobility_statistics#Origin_of_students_from_abroad.

103. "Collateral Damage? Research Collaboration in an Age of U.S.-China Competition," CSIS, June 4, 2019, <https://www.csis.org/events/collateral-damage-research-collaboration-age-us-china-competition>.

104. James Laurenceson and Michael Zhou, "Partners in knowledge creation: trends in Australia-China research collaboration and future challenges," Australia-China Relations Institute, July 2019, https://www.australiachinarelations.org/sites/default/files/20190719%20Australia-China%20Relations%20Institute%20working%20paper_Partners%20in%20knowledge%20creation%20-%20trends%20in%20Australia-China%20research%20collaboration%20and%20future%20challenges.pdf.

105. "Research Landscape in China," UK Research and Innovation, <https://www.ukri.org/research/international/ukri-international-offices/ukri-china/research-landscape-in-china/>.

106. Zhang Erchi and Tang Ziyi, "Siemens to Open China R&D Center to tap Digitization Push," Caixin, May 17, 2019, <https://www.caixinglobal.com/2019-05-17/siemens-to-open-china-rd-center-to-tap-digitization-push-101417034.html>.

107. Takashi Kawakami, "Germany's Merck plans expansion at Chinese R&D hubs," *Nikkei Asian Review*, November 30, 2018, <https://asia.nikkei.com/Business/Companies/Germany-s-Merck-plans-expansion-at-Chinese-R-D-hubs>.

108. Norihiko Shirouzu, "Daimler to open new R&D center in China to accelerate localization," Reuters, November 14, 2018, <https://www.reuters.com/article/us-china-autos-daimler/daimler-to-open-new-rd-center-in-china-to-accelerate-localization-idUSKCN1NJ15D>.

Several allied government programs actively encourage these partnerships. The European Union's Horizon 2020 program, which provides roughly \$90 billion in research funding across EU member states, includes a China-EU co-funding mechanism.¹⁰⁹ Through this initiative, China's Ministry of Science and Technology partnered with the European Commission to reserve \$141 million to support joint projects for 2018-2020. In April, Australia announced nearly \$5 million in research grants for five joint university research centers, to be matched by the Chinese government, as part of the Australia-China Science and Research Fund.¹¹⁰

At the same time, a handful of countries have begun to adopt policies that would more closely scrutinize IP resulting from research collaboration. Earlier this year, Japan's Ministry of Economy, Trade and Industry (METI) announced it would review its academic guidelines and set new rules to prevent leaks of dual-use technologies from universities.¹¹¹ The regulations, scheduled for release by March 2020, would be the first to control university projects with foreign scientists.¹¹² Similarly, in August, Australia's Department of Education announced a task force to better protect universities against foreign interference and unveiled best practices developed in partnership with universities.¹¹³ Last fall, Canada's national intelligence agency warned of foreign actors exploiting Canadian research and routinely meets with universities to discuss risks.¹¹⁴ The German government has also stepped-up its engagement with academic and research institutions focusing on information dissemination and compliance requirements. The 2019 EU-China Strategic Outlook, which labels China a "strategic rival promoting alternative models of governance," includes a reference to "rules for participation and dissemination" related to the results of research and innovation.¹¹⁵

As the United States reevaluates policies toward foreign research collaboration, engagement with allies and partners will be critical. Engagement should focus on raising awareness, exchanging best practices, and reaffirming shared principles guiding S&T collaboration. Given the global nature of scientific discovery and global competition for world-class talent, if other countries do not adopt similar frameworks, the United States risks isolating itself while failing to adequately address IP theft and threats to research integrity.

109. "What is Horizon 2020," European Commission, <https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020>; "People's Republic of China: Country Page," European Commission, http://ec.europa.eu/research/participants/data/ref/h2020/other/hi/h2020_localsupp_china_en.pdf.

110. Kirsty Needham, "Major boost to Australia-China science ties," *Sydney Morning Herald*, April 10, 2019, <https://www.smh.com.au/world/asia/connecting-our-best-minds-major-boost-to-australia-china-science-ties-20190409-p51cdg.html>.

111. Kenji Shimizu, "Japan government to draw up guidelines for universities to prevent technology drain," *Mainichi*, April 24, 2019, <https://mainichi.jp/english/articles/20190424/p2a/00m/0bu/005000c>.

112. Kyodo, "Japan drafting guidelines to stop technology leaks from universities working with foreign firms," *Japan Times*, April 24, 2019, <https://www.japantimes.co.jp/news/2019/04/24/national/japan-drafting-guidelines-stop-technology-leaks-universities-working-foreign-firms/#.XVsFl-hKiU>.

113. "Establishment of a University Foreign Interference Taskforce," Australian Government Department of Education, August 29, 2019, <https://www.education.gov.au/news/establishment-university-foreign-interference-taskforce>.

114. Nathan Vanderklippe, "Foreign espionage of Canadian research a risk to national research, CSIS warns," *Globe and Mail*, October 30, 2018, <https://www.theglobeandmail.com/world/article-foreign-espionage-of-canadian-research-a-risk-to-national-interests/>.

115. "Joint Communication to the European Parliament, the European Council, and the Council," European Commission, December 3, 2019, <https://ec.europa.eu/commission/sites/beta-political/files/communication-eu-china-a-strategic-outlook.pdf>.

A Way Forward

The following recommendations aim to balance openness with the need to protect national security and prioritize the need to invest in innovative capacity at home. They are based on available unclassified information which reveals a very real threat posed by a small fraction of foreign researchers working illicitly to gain access to sensitive science and technology. Government, academia, and the private sector would need to reassess the trade-offs between openness and security should new information indicate a more systemic problem.

1. Strengthen efforts to produce domestic STEM talent and retain foreign researchers.

The United States will only remain at the innovation frontier by investing in research and human capital development. This includes improving STEM outcomes in primary and secondary education, attracting and retaining more women and minorities in STEM fields, and expanding pathways for foreign students to remain in the country after completing their degrees, without reliance on funding from sources of concern. While specific education and immigration policies are outside the scope of this report, they are an integral part of U.S. innovation leadership.

2. Develop a realistic inventory of global innovation leadership. An informed view of the landscape is needed to craft policies that preserve U.S. access to cutting-edge science. Policymakers should leverage an ongoing study by the National Science Foundation and the JASON advisory group and ensure funding for regular reviews of science and technology leadership.^{116,117}

3. Limit restrictions on collaboration only to those areas that pose an identified threat to national security. Consistent with NSDD 189, federal agencies should articulate clear, narrow restrictions on sensitive projects while exempting fundamental research from heightened control. In general, attention should focus on graduate and post-doctoral researchers working on applied research with military

116. "Statement on NSF's commitment to secure, open international research collaboration," NSF, https://www.nsf.gov/news/news_summ.jsp?cntn_id=298852&WT.mc_id=USNSF_51&WT.mc_ev=click.

117. JASON is an independent scientific advisory group of around 60 top U.S. physicists and scientists with top-secret security clearances which has provided consulting services to the U.S. government on defense and technology issues since 1960. JASON receives approximately \$8 million annually in federal funding, but the Pentagon is considering disbanding the group. As an independent advisory group, JASON is subject to President Trump's June 2019 executive order that federal agencies slash a third of their independent advisory committees by September 30.

applications, not undergraduate students. To the extent unacceptable research-related risks to national security persist, policies may need to be further refined. In this respect, outreach and coordination activities outlined in Recommendations 4 and 5 are of critical importance.

4. Standardize federal policy guidance to agencies and research institutions.

Overlapping regulations from individual agencies increase costs of compliance and add complexity. Building on the JCORE launch, OSTP should deepen interagency efforts to develop common policy guidance and disclosure best practices for funders and academic institutions. Recommendations should include oversight and enforcement mechanisms that respect due process and are transparent and open to public comment, where possible. These policies should undergo regular review to ensure they adequately address risks.

5. Deepen processes to connect government and non-government stakeholders.

Setting policy for this complex issue requires not only coordination among federal agencies but also cooperation with academia and the private sector. Congress and the administration should reaffirm their support for scientific advisory boards, such as JASON and the National Academies of Sciences, Engineering, and Medicine, and consult these groups during the policy formation process.

6. Enhance efforts to enforce existing policies. Existing policies on peer review, disclosure, and classification have the potential to address many research leakage vulnerabilities, but enforcement by universities and research institutions remains an issue. Working with industry, academic associations, and individual universities, the U.S. government should codify and disseminate best practices. Violations of IP protections and academic integrity protocols should be handled through enforcement actions, which may require additional funding for compliance officers, including in federal grants. This effort could expand on Section 1286 of the 2019 NDAA and its development of training and other support for academic institutions.

7. Work with allies and partners in areas of highest concern. A unilateral approach risks losing talent without addressing risks to academic integrity and national security. Outreach to allies and partners should be supported by specific evidence of activity of concern, such as military-sponsored researchers, rather than broad threats of IP leakage. Deepening information and intelligence sharing will help educate allies and partners on high-risk areas where restrictions may be necessary.

About the Authors

Stephanie Segal is a senior fellow of the CSIS Simon Chair in Political Economy. Previously, she served as codirector of the East Asia Office at the U.S. Department of the Treasury. Prior to the Department of the Treasury, she was senior economist at the International Monetary Fund (IMF), where she covered a range of emerging market and advanced country economies. Earlier in her career, Ms. Segal served as an economist in the Western Hemisphere, Southeast Asia, and International Monetary Policy offices at the Department of the Treasury; as an adviser to the U.S. director at the IMF; and as an analyst and then associate in mergers and acquisitions at J.P. Morgan in New York. She earned her master's degree from Johns Hopkins University's School of Advanced International Studies and her undergraduate degree from the University of North Carolina at Chapel Hill.

Dylan Gerstel is a research assistant with the Simon Chair in Political Economy at CSIS, where he focuses on U.S. global economic leadership. Prior to joining CSIS, he worked as an associate at Hamilton Place Strategies and as an economic policy intern for Vice President Joe Biden. He graduated Phi Beta Kappa from Swarthmore College with a B.A. in political science and statistics.

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1616 Rhode Island Avenue NW
Washington, DC 20036
202 887 0200 | www.csis.org