

Independent Task Force Report No. 77

Innovation and National Security

Keeping Our Edge

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ENDNOTES

1. For the growing debate on China policy see, for example, Kurt M. Campbell and Ely Ratner, "The China Reckoning: How Beijing Defied American Expectations," *Foreign Affairs*, March/April 2018, <http://foreignaffairs.com/articles/china/2018-02-13/china-reckoning>; Larry Diamond and Orville Schell, ed., *China's Influence & American Interests: Promoting Constructive Vigilance* (Stanford, CA: Hoover Institution, 2018), http://hoover.org/sites/default/files/research/docs/00_diamond-schell-chinas-influence-and-american-interests.pdf; Task Force on U.S.-China Policy, Orville Schell and Susan L. Shirk, ed., *Course Correction: Toward an Effective and Sustainable China Policy* (New York: Asia Society, 2019), http://asiasociety.org/sites/default/files/inline-files/CourseCorrection_FINAL_2.7.19_1.pdf; M. Taylor Fravel, J. Stapleton Roy, Michael D. Swaine, Susan A. Thornton, and Ezra Voge, "China Is Not an Enemy," *Washington Post*, July 3, 2019, http://washingtonpost.com/opinions/making-china-a-us-enemy-is-counterproductive/2019/07/02/647d49d0-9bfa-11e9-b27f-ed2942f73d70_story.html.
2. See, for example, Robert Solow, "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics* 70 (February 1956): 65–94 and "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics* 39 (August 1957): 312–20; Paul Romer, "Endogenous Technological Change," *Journal of Political Economy*, vol. 98, no. 5 (October 1990): S71–S102 and "The Origins of Endogenous Growth," *Journal of Economic Perspectives*, vol. 8, no. 1 (1994): 3–22; James Manyika, Daniel Pachod, and Michael Park, "Translating Innovation Into U.S. Growth: An Advanced-Industries Perspective," McKinsey & Company, May 2011, <http://mckinsey.com/industries/public-sector/our-insights/translating-innovation-into-us-growth-an-advanced-industries-perspective>; James Manyika and Charles Roxburgh, "The Great Transformer: The Impact of the Internet on Economic Growth and Prosperity," McKinsey Global Institute, October 2011.
3. Commission on the Theft of American Intellectual Property, *The IP Commission Report* (Washington, DC: National Bureau of Asian Research, May 2013), http://ipcommission.org/report/IP_Commission_Report_052213.pdf.
4. Klaus Schwab, "The Fourth Industrial Revolution," *Foreign Affairs*, December 12, 2015, <http://foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution>.

5. Richard Dobbs, James Manyika, and Jonathan Woetzel, *No Ordinary Disruption: The Four Global Forces Breaking All the Trends* (New York: Public Affairs, 2015).
6. Joe Andrews, “23andMe Competitor Veritas Genetics Slashes Price of Whole Genome Sequencing 40% to \$600,” CNBC, July 1, 2019, <http://cnbc.com/2019/07/01/for-600-veritas-genetics-sequences-6point4-billion-letters-of-your-dna.html>.
7. Edward Alden and Laura Taylor-Kale, *The Work Ahead: Machines, Skills, and U.S. Leadership in the Twenty-First Century* (New York: Council on Foreign Relations, 2018), <http://cfr.org/report/the-work-ahead/report>.
8. Carl Benedikt Frey and Michael A. Osborne, “The Future of Employment: How Susceptible Are Jobs to Computerization?,” Oxford Martin School, September 1, 2013, <https://www.oxfordmartin.ox.ac.uk/publications/the-future-of-employment>; John Hawksorth, Richard Berriman, and Saloni Goel, “Will Robots Really Steal Our Jobs? An International Analysis of the Potential Long Term Impact of Automation,” PwC, 2018, http://pwc.com/hu/hu/kiadvanyok/assets/pdf/impact_of_automation_on_jobs.pdf; Ljubica Nedelkoska and Glenda Quintini, “Automation, Skills Use and Training,” OECD Social, Employment and Migration Working Papers no. 202 (Paris: OECD Publishing, 2018), <http://doi.org/10.1787/2e2f4eea-en>; James Manyika, Susan Lund, Michael Chui, Jacques Bughin, Jonathan Woetzel, Parul Batra, Ryan Ko, and Saurabh Sanghvi, “Jobs Lost, Jobs Gained: What the Future of Work Will Mean for Jobs, Skills, and Wages,” McKinsey Global Institute, November 2017, <http://mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages>.
9. Vannevar Bush, *Science: The Endless Frontier, A Report to the President* (Washington, DC: Director of the Office of Scientific Research and Development, July 1945), <http://nsf.gov/od/lpa/nsf50/vbush1945.htm>.
10. Mariana Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths* (Anthem, 2013).
11. “National Defense Education and Innovation Initiative: Meeting America’s Economic and Security Challenges in the 21st Century,” Association of American Universities, January 2006, <http://aaup.edu/sites/default/files/AAU-Files/Key-Issues/Innovation-Competitiveness/Report-NDEII.pdf>.
12. L. Fleming, H. Greene, G. Li, M. Marx, and D. Yao, “Government-Funded Research Increasingly Fuels Innovation,” *Science* (June 21, 2019): 1139–1141.
13. Peter Singer, “Federally Supported Innovations,” *Information Technology & Innovation Foundation*, February 3, 2015, <http://itif.org/publications/2014/02/03/federally-supported-innovations>; Harvard Business School, “Public Funding Essential for Advances in Biomedical Research: Cuts in National Institutes of Health Budget Could Impact Innovation,” *ScienceDaily*, March 30, 2018, <http://sciencedaily.com/releases/2017/03/170330142303.htm>.
14. Simon Tripp and Martin Grueber, “Economic Impact of the Human Genome Project,” Battelle Memorial Institute, May 2011, <http://battelle.org/docs/default-source/misc/battelle-2011-misc-economic-impact-human-genome-project.pdf>.
15. Center for American Entrepreneurship, “Immigrant Founders of the 2017 Fortune 500,” <http://startupsusa.org/fortune500>.

16. David Ewalt, "Reuters Top 100: The World's Most Innovative Universities—2017," Reuters, September 27, 2017, <http://reuters.com/article/us-amers-reuters-ranking-innovative-univ/reuters-top-100-the-worlds-most-innovative-universities-2017-idUSKCN1C209R>.
17. J. John Wu, "Why U.S. Business R&D Is Not as Strong as It Appears," ITIF, June 2018, <http://www2.itif.org/2018-us-business-rd.pdf>.
18. Timothy Martin, "American Tech Firms Are Winning the R&D Spending Race With China," *Wall Street Journal*, October 30, 2018, <http://wsj.com/articles/american-tech-firms-are-winning-the-r-d-spending-race-with-china-1540873318>.
19. Pitchbook and National Venture Capital Association, *Venture Monitor* 4Q 2018, http://nvca.org/wp-content/uploads/delightful-downloads/2019/01/4Q_2018_PitchBook_NVCA_Venture_Monitor-1.pdf.
20. National Science Board, "Global Trends in Trade of Knowledge- and Technology-Intensive Products and Services," in *Science and Engineering Indicators* 2018 (January 2018), <http://nsf.gov/statistics/2018/nsb20181/report/sections/industry-technology-and-the-global-marketplace/global-trends-in-trade-of-knowledge-and-technology-intensive-products-and-services>.
21. Mark Boroush, "U.S. R&D Increased by \$20 Billion in 2015, to \$495 Billion; Estimates for 2016 Indicate a Rise to \$510 Billion," InfoBrief NSF 18-306, National Science Foundation, December 14, 2017, <http://nsf.gov/statistics/2018/nsf18306>.
22. "US R&D Spending at All-Time High, Federal Share Reaches Record Low," AIP, November 8, 2016, <http://aip.org/fyi/2016/us-rd-spending-all-time-high-federal-share-reaches-record-low>.
23. Jeffrey Mervis, "Data Check: U.S. Government Share of Basic Research Funding Falls Below 50%," *Science*, March 9, 2017, <http://sciencemag.org/news/2017/03/data-check-us-government-share-basic-research-funding-falls-below-50>.
24. Matt Hourihan and David Parkes, "Omnibus Would Provide Largest Research Increase in Nearly a Decade," AAAS, March 22, 2018, <http://aaas.org/news/omnibus-would-provide-largest-research-increase-nearly-decade>.
25. Joel Achenbach, Ben Guarino, Sarah Kaplan, and Brady Dennis, "Trump Budget Seeks Cuts in Science Funding," *Washington Post*, March 11, 2019, <http://washingtonpost.com/science/2019/03/11/trump-budget-seeks-cuts-science-funding>.
26. Robert Atkinson, Stephen Ezell, and John Wu, "Why Tariffs on Chinese ICT Imports Would Harm the U.S. Economy," ITIF, March 16, 2018, <http://itif.org/publications/2018/03/16/why-tariffs-chinese-ict-imports-would-harm-us-economy>.
27. Chad Brown and Eva Zhang, "Measuring Trump's 2018 Trade Protection: Five Takeaways," *Trade and Investment Policy Watch* (blog), PIIE, February 15, 2019, <http://piie.com/blogs/trade-investment-policy-watch/measuring-trumps-2018-trade-protection-five-takeaways>.
28. European Commission, "EU-China—A Strategic Outlook," June 12, 2019, <http://ec.europa.eu/commission/sites/beta-political/files/communication-eu-china-a-strategic-outlook.pdf>.
29. Edward Alden, "Trump and the TPP: Giving Away Something for Nothing," *Renewing*

America (blog), Council on Foreign Relations, January 23, 2017, <http://cfr.org/blog/trump-and-tpp-giving-away-something-nothing>.

30. Ehsan Masood, "How China Is Redrawing the Map of World Science," *Nature*, May 1, 2019, <http://nature.com/immersive/d41586-019-01124-7/index.html>.
31. Sari Pekkala Kerr, William Kerr, Çağlar Özden, and Christopher Parsons, *High-Skilled Migration and Agglomeration*, NBER Working Paper (December 2016), <http://nber.org/papers/w22926>; Michelle Hackman and Douglas Belkin, "Fewer International Students Heading to the U.S.," *Wall Street Journal*, November 13, 2018, <http://wsj.com/articles/fewer-international-students-heading-to-the-u-s-1542105004>.
32. "Travel Ban Throws Research, Academic Exchange Into Turmoil," CNBC, January 31, 2017, <http://cnbc.com/2017/01/31/travel-ban-throws-research-academic-exchange-into-turmoil.html>; Richard Chirgwin, "IETF Moves Meeting From USA to Canada to Dodge Trump Travel Ban," *Register*, July 16, 2017, http://theregister.co.uk/2017/07/16/trump_travel_ban_sees_ietf_move_meeting_from_usa_to_canada.
33. Issie Lapowsky, "Visa Rejections for Tech Workers Spike Under Trump," *Wired*, April 25, 2019, <http://wired.com/story/h-1b-visa-rejections-spike-under-trump>.
34. Rani Molla, "U.S. Companies Are Moving Tech Jobs to Canada Rather Than Deal With Trump's Immigration Policies," *Recode*, March 19, 2019, <http://recode.net/2019/3/19/18264391/us-tech-jobs-canada-immigration-policies-trump>.
35. Louise Radnofsky, "U.S. Changes Visa Process for High-Skilled Workers," *Wall Street Journal*, January 30, 2019.
36. Yi Xue and Richard C. Larson, "STEM Crisis or STEM Surplus? Yes and Yes," *Monthly Labor Review*, U.S. Bureau of Labor Statistics, May 2015, <http://doi.org/10.21916/mlr.2015.14>.
37. Xueying Han and Richard Applebaum, "Will They Stay or Will They Go? International STEM Students Are Up for Grabs," Kauffman Foundation, July 2016, http://kauffman.org/-/media/kauffman_org/research-reports-and-covers/2016/stem_students_final.pdf.
38. The STEM Imperative, Smithsonian Institution, <http://ssec.si.edu/stem-imperative>.
39. Celestine Bohlen, "Making Gains for Women in STEM Fields Will Take More Effort," *New York Times*, November 20, 2018, <http://nytimes.com/2018/11/20/world/europe/women-in-stem.html>.
40. Scott E. Page, *The Difference* (Princeton, NJ: Princeton University Press, 2007).
41. Donald Hicks, *Final Report of the Defense Science Board Task Force on Globalization and Security* (Washington, DC: Defense Science Board, 1999), ii.
42. Ben FitzGerald, Alexandra Sander, and Jacqueline Parziale, *Future Foundry: A New Strategic Approach to Military-Technical Advantage* (Washington, DC: CNAS, 2016), <http://cnas.org/publications/reports/future-foundry>.
43. "SASC Chairman John McCain Remarks on Top Defense Priorities for 114th Congress at CSIS," Senate Armed Services Committee, March 26, 2016, <http://armed-services.senate.gov/press-releases/sasc-chairman-john-mccain-remarks-on-top-defense-priorities-for-114th-congress-at-csis>.

44. *Summary of the 2018 National Defense Strategy of the United States* (Washington, DC: Department of Defense, 2018), <http://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.
45. J. Michael McQuade and Richard M. Murray, *Software Is Never Done: Refactoring the Acquisition Code for Competitive Advantage* (Defense Innovation Board, 2019), http://media.defense.gov/2019/apr/30/2002124828/-1/-1/0/softwareisneverdone_refactoringtheacquisitioncodeforcompetitiveadvantage_final.swap.report.pdf.
46. Jack Moore, "Here Are 10 of the Oldest IT Systems in the Federal Government," *Nextgov*, May 25, 2016, <http://nextgov.com/cio-briefing/2016/05/10-oldest-it-systems-federal-government/128599>.
47. Dennis Fisher, "Groundbreaking Cyber Fast Track Research Program Ending," *Threatpost*, March 6, 2016, <http://threatpost.com/groundbreaking-cyber-fast-track-research-program-ending-030613/77594>; Fred Kaplan, "The Pentagon's Innovation Experiment," *MIT Technology Review*, December 19, 2016, <http://technologyreview.com/s/603084/the-pentagons-innovation-experiment>.
48. Raj Shah, "Arceo's Shah on New Company, Defense Innovation, Tenure at DIUx," interview by Vago Muradian, *Defense and Aerospace Report*, December 28, 2018, <http://youtube.com/watch?v=Ool1ctvS0h8>; Mike Cerre, "How the Pentagon Joins Forces With Silicon Valley Startups," *PBS Newshour*, August 15, 2018, <http://pbs.org/newshour/show/how-the-pentagon-joins-forces-with-silicon-valley-startups>.
49. *Promoting DOD's Culture of Innovation: Statement Before the House Armed Services Committee*, 115th Cong. (2018) (statement of Dr. Eric Schmidt, Chairman, Defense Innovation Board, Department of Defense), <http://docs.house.gov/meetings/AS/AS00/20180417/108132/HHRG-115-AS00-Wstate-SchmidtE-20180417.pdf>.
50. Mark Wallace, "The U.S. Air Force Learned to Code—and Saved the Pentagon Millions," *Fast Company*, July 5, 2018, <http://fastcompany.com/40588729/the-air-force-learned-to-code-and-saved-the-pentagon-millions>.
51. Issie Lapowsky, "The Pentagon Is Building a Dream Team of Tech-Savvy Soldiers," *Wired*, July 2, 2018, <http://wired.com/story/pentagon-dream-team-tech-savvy-soldiers>.
52. Martin Martishak, "Defense Digital Service Chief Stepping Down After 'Nerd Tour of Duty,'" *Politico*, April 23, 2019, <http://politico.com/story/2019/04/23/chris-lynch-leaving-defense-digital-1373893>.
53. Ryan Mac, "Behind the Crash of 3D Robotics, North America's Most Promising Drone Company," *Forbes*, October 5, 2016, <http://forbes.com/sites/ryanmac/2016/10/05/3d-robotics-solo-crash-chris-anderson>.
54. National Defense Strategy Commission, *Providing for the Common Defense: The Assessment and Recommendations of the National Defense Strategy Commission* (Washington, DC: U.S. Institute of Peace, November 13, 2018), <http://usip.org/sites/default/files/2018-11/providing-for-the-common-defense.pdf>; Interagency Task Force in Fulfillment of Executive Order 13806, *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States*, Report to President Donald J. Trump, September 2018, <http://media.defense.gov/2018/oct/05/2002048904/-1/-1/1/assessing-and-strengthening-the-manufacturing-and-%20defense-industrial-base-and-supply-chain-resiliency.pdf>.

55. Adam Segal, *Rebuilding Trust Between Silicon Valley and Washington* (New York: Council on Foreign Relations, 2017), <http://cfr.org/report/rebuilding-trust-between-silicon-valley-and-washington>.
56. Scott Shane and Daisuke Wakabayashi, "Google Will Not Renew Pentagon Contract That Upset Employees," *New York Times*, June 1, 2018, <http://nytimes.com/2018/06/01/technology/google-pentagon-project-maven.html>.
57. Zachary Freyer Biggs, "Inside the Pentagon's Plans to Win Over Silicon Valley's AI Experts," *Wired*, December 21, 2018, <http://wired.com/story/inside-the-pentagons-plan-to-win-over-silicon-valleys-ai-experts>.
58. Joseph Bernstein, "Survey: 51% Of Tech Industry Workers Believe President Trump Has a Point About the Media Creating Fake News," *BuzzFeed*, February 23, 2019, <http://buzzfeednews.com/article/josephbernstein/tech-industry-survey>.
59. Heather Kelly, "Jeff Bezos: Amazon Will Keep Working With the DOD," *CNN*, October 15, 2018, <http://cnn.com/2018/10/15/tech/jeff-bezos-wired/index.html>.
60. John Sargent Jr., "Global Research and Development Expenditures: Fact Sheet," Congressional Research Service, June 27, 2018, <http://fas.org/sgp/crs/misc/R44283.pdf>; "Global R&D Continues Growth With Less Government Support," *R&D Magazine*, 2018, http://digital.rdmag.com/researchanddevelopment/2018_global_r_d_funding_forecast?pg=2#pg2.
61. OECD Data, "Gross Domestic Spending on R&D," last updated 2019, <http://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm>.
62. Dennis Normille, "China Narrows U.S. Lead in R&D Spending," *Science*, October 19, 2018, <http://science.sciencemag.org/content/362/6412/276>; "The Rise of China in Science and Engineering: 2018," National Science Board, <http://nsf.gov/nsb/sei/one-pagers/China-2018.pdf>.
63. Normille, "China Narrows U.S. Lead in R&D Spending."
64. "China Now Produces Twice as Many Graduates a Year as the United States," World Economic Forum, April 13, 2017, <http://weforum.org/agenda/2017/04/higher-education-in-china-has-boomed-in-the-last-decade>; "Back to School Statistics," National Center for Education Statistics, <http://nces.ed.gov/fastfacts/display.asp?id=372>.
65. Richard P. Appelbaum and Xueying Han, "China's Science, Technology, Engineering, and Mathematics (STEM) Research Environment: A Snapshot," *PLOS One*, April 3, 2018, <https://doi.org/10.1371/journal.pone.0195347>.
66. National Science Board, "International S&E Higher Education," in *Science & Engineering Indicators 2018*, <http://nsf.gov/statistics/2018/nsb20181/report/sections/higher-education-in-science-and-engineering/international-s-e-higher-education>.
67. Dennis Normille, "With Generous Funding and Top-Tier Jobs, China Seeks to Lure Science Talent From Abroad," *Science*, June 5, 2018, <http://sciencemag.org/news/2018/06/generous-funding-and-top-tier-jobs-china-seeks-lure-science-talent-abroad>.
68. Hepeng Jia, "China's Plan to Recruit Talented Researchers," *Nature*, January 17, 2018, <http://nature.com/articles/d41586-018-00538-z>.

69. Kate O'Keeffe and Timothy Puko, "U.S. Targets Efforts by China, Others to Recruit Government Scientists," *Wall Street Journal*, June 10, 2019, <http://wsj.com/articles/energy-department-bans-personnel-from-foreign-talent-recruitment-programs-11560182546>.
70. "Hyperion: China Maintains Lead in Race to Exascale," *HPC Wire*, June 28, 2018, <http://hpcwire.com/2018/06/28/hyperion-china-maintains-lead-in-race-to-exascale>. It is worth noting that the United States still excels in terms of supercomputing software, which is critical to harnessing the power of supercomputers for useful applications.
71. Shannon Ellis, "Biotech Booms in China," *Nature*, January 17, 2018, <http://nature.com/articles/d41586-018-00542-3>.
72. Peng Ying, "AI Sector Sees Big Investment, Financing in 2017: Report," *Xinhua*, February 24, 2018, http://xinhuanet.com/english/2018-02/24/c_136997279.htm.
73. Yujia He, "How China Is Preparing for an AI-Powered Future," Wilson Center, June 2017, http://wilsoncenter.org/sites/default/files/how_china_is_preparing_for_ai_powered_future.pdf.
74. Yoav Shoham, Raymond Perrault, Erik Brynjolfsson, Jack Clark, James Manyika, Juan Carlos Niebles, Terah Lyons, John Etchemendy, Barbara Grosz and Zoe Bauer, *AI Index 2018 Annual Report* (Stanford, CA: Stanford University, December 2018), <http://cdn.aiindex.org/2018/AI%20Index%202018%20Annual%20Report.pdf>; Jun Zhu, Tiejun Huang, Wenguang Chen, and Wen Gao, "The Future of Artificial Intelligence in China," *Communications of the ACM* 61, no. 11 (November 2018): 44–45.
75. He, "How China Is Preparing for an AI-Powered Future"; Chen Xi, "China to Open 400 Big Data, AI Majors in Universities for Global Competition," *Global Times*, February 27, 2019.
76. Will Knight, "China's Huawei Has Big Ambitions to Weaken the U.S. Grip on AI Leadership," *Technology Review*, March 4, 2019, <http://technologyreview.com/s/612914/chinas-huawei-has-big-ambitions-to-weaken-the-uss-grip-on-ai-leadership>.
77. Jason Rowley, "Q4 2018 Closes Out a Record Year for the Global VC Market," *Crunchbase News*, January 7, 2019, <http://news.crunchbase.com/news/q4-2018-closes-out-a-record-year-for-the-global-vc-market>.
78. Lorand Laskai, "In Drive for Tech Independence, Xi Doubles Down on Civil-Military Fusion," *China Brief*, May 9, 2018, <http://jamestown.org/program/in-drive-for-tech-independence-xi-doubles-down-on-civil-military-fusion>.
79. Adam Segal, "When China Rules the Web," *Foreign Affairs*, September/October 2018.
80. National Science Board, "Gross Expenditure on R&D for Selected Countries, by Performing Sector or Source of Funds: 2015 or Most Recent Year," in *Science and Engineering Indicators 2018* (January 2018), accessed July 9, 2019, <http://nsf.gov/statistics/2018/nsb20181/data/tables>.
81. Adam Segal, "Seizing Core Technologies: China Responds to U.S. Technology Competition," *China Leadership Monitor*, June 1, 2019, <http://prcleader.org/segal-clm-60>.

82. White House, Presidential Executive Order on Streamlining and Expediting Requests to Locate Broadband Facilities in Rural America, January 8, 2018, <http://whitehouse.gov/presidential-actions/presidential-executive-order-streamlining-expediting-requests-locate-broadband-facilities-rural-america>; Committee on STEM Education of the National Science & Technology Council, *Charting a Course for Success: America's Strategy for STEM Education* (December 2018), <http://whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf>.
83. "FY19 Budget Request: Defense S&T Stable as DOD Focuses on Technology Transition," American Institute of Physics, February 23, 2018, <http://aip.org/fyi/2018/fy19-budget-request-defense-st-stable-dod-focuses-technology-transition>.
84. "FY2019 Department of Defense Appropriations," Association of American Universities, September 28, 2018, <http://aau.edu/sites/default/files/AAU-Files/Key-Issues/Federal-Budget/Appropriations-Tables/Defense-FY19-Funding-Table.pdf>; "Budget," Defense Advanced Research Projects Agency, accessed July 9, 2019, <http://darpa.mil/about-us/budget>.
85. Lauren C. Williams, "DIUx Gets a Big Boost in FY19 Budget," FCW, February 12, 2018, <http://fcw.com/articles/2018/02/12/budget-williams-do.aspx>; Jonathan Behrens, "FY20 Budget Request: DOD Science and Technology," American Institute of Physics, March 28, 2019.
86. Stephen Rodriguez and Evanna Hu, "America Needs an AI Strategy. Just Ask Google," *National Review*, July 18, 2018, <http://nationalreview.com/2018/07/america-needs-an-ai-strategy-to-remain-global-technology-powerhouse>.
87. Sydney Freedberg Jr., "Joint Artificial Intelligence Center Created Under DoD CIO," *Breaking Defense*, June 29, 2018, <http://breakingdefense.com/2018/06/joint-artificial-intelligence-center-created-under-dod-cio>.
88. White House, FY 2020 Administration Research and Development Budget Priorities, July 31, 2018, <http://whitehouse.gov/wp-content/uploads/2018/07/M-18-22.pdf>; Defense Advanced Research Projects Agency, AI Next Campaign, <http://darpa.mil/work-with-us/ai-next-campaign>.
89. White House Office of Science and Technology Policy, "Summary of the 2018 White House Summit on Artificial Intelligence for American Industry," May 10, 2018, <http://whitehouse.gov/wp-content/uploads/2018/05/Summary-Report-of-White-House-AI-Summit.pdf>.
90. White House, "Accelerating America's Leadership in Artificial Intelligence," February 11, 2019, <http://whitehouse.gov/articles/accelerating-americas-leadership-in-artificial-intelligence>.
91. U.S. Department of Defense, "Summary of the 2018 Department of Defense Artificial Intelligence Strategy," February 12, 2019, <http://media.defense.gov/2019/feb/12/2002088963/-1/-1/1/summary-of-dod-ai-strategy.pdf>.
92. Megan Lamberth, "The White House and Defense Department Unveiled AI Strategies. Now What?" C4ISRNet, February 27, 2019, <http://c4isrnet.com/opinion/2019/02/27/the-white-house-and-defense-department-unveiled-ai-strategies-now-what>.
93. White House, Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America's Future, October 25, 2018, <http://whitehouse.gov/presidential>.

actions/presidential-memorandum-developing-sustainable-spectrum-strategy-america's-future.

94. Brian Fung, "5G Is About to Get a Big Boost From Trump and the FCC," *Washington Post*, April 12, 2019, <http://washingtonpost.com/technology/2019/04/12/g-is-about-get-big-boost-trump-fcc>.
95. Dan Strumpf, "Huawei Expects \$30 Billion Revenue Hit From U.S. Clampdown," *Wall Street Journal*, June 17, 2019, <http://wsj.com/articles/u-s-clampdown-to-cost-huawei-30-billion-in-revenue-founder-says-11560766359>.
96. Peter Baker and Keith Bradsher, "Trump and Xi Agree to Restart Trade Talks, Avoiding Escalation in Tariff War," *New York Times*, June 29, 2019, <http://nytimes.com/2019/06/29/world/asia/g20-trump-xi-trade-talks.html>; "White House Official: New Sales to China's Huawei to Cover Only Widely Available Goods," Reuters, June 30, 2019, <http://uk.reuters.com/article/us-usa-trade-china-huawei-tech/white-house-official-new-sales-to-chinas-huawei-to-cover-only-widely-available-goods-idUKKCN1TV0PO>.
97. Julian Barnes and Adam Satariano, "U.S. Campaign to Ban Huawei Overseas Stumbles as Allies Resist," *New York Times*, March 17, 2019, <http://nytimes.com/2019/03/17/us/politics/huawei-ban.html>.
98. Marco Rubio (@marcorubio), "If President Trump has agreed to reverse recent sanctions against #Huawei he has made a catastrophic mistake . . .," Twitter, June 29, 2019, 7:34 a.m., <http://twitter.com/marcorubio/status/1144977483101593601>.
99. Rhodium Group and National Committee on U.S.-China Relations, "Two Way Street: 2019 Update U.S.-China Investment Trends," May 7, 2019, http://arraysproduction-0dot22.s3.amazonaws.com/rhodiumgroup/assets/icon/RHG_TWS-2019_Executive-Summary_7May2019.pdf.
100. Brian Gormley, "Startups Rethink Foreign Funding as U.S. Tightens Security Reviews," *Wall Street Journal*, March 15, 2019, <http://wsj.com/articles/startups-rethink-foreign-funding-as-u-s-tightens-security-reviews-11552649400>.
101. Rolfe Winkler, "Chinese Cash That Powered Silicon Valley Is Suddenly Toxic," *Wall Street Journal*, June 11, 2019, <http://wsj.com/articles/chinese-cash-is-suddenly-toxic-in-silicon-valley-following-u-s-pressure-campaign-11560263302>.
102. Christina Farr and Ari Levy, "The Trump Administration Is Forcing This Health Start-Up That Took Chinese Money Into a Fire Sale," CNBC, April 4, 2019, <http://cnbc.com/2019/04/04/cfus-forces-patientslikeme-into-fire-sale-booting-chinese-investor.html>.
103. Heather Somerville, "Chinese Tech Investors Flee Silicon Valley as Trump Tightens Scrutiny," Reuters, <http://reuters.com/article/us-venture-china-regulation-insight/chinese-tech-investors-flee-silicon-valley-as-trump-tightens-scrutiny-idUSKCN1P10CB>.
104. "A Conversation With Christopher Wray," Council on Foreign Relations, April 26, 2019, <http://cfr.org/event/conversation-christopher-wray-0>.
105. Elizabeth Redden, "Science vs. Security," *Inside Higher Ed*, April 16, 2019, <http://insidehighered.com/news/2019/04/16/federal-granting-agencies-and-lawmakers-step-scrutiny-foreign-research>.

106. Patricia Zengerle and Matt Spetalnick, "Exclusive: Fearing Espionage, U.S. Weighs Tighter Rules on Chinese Students," Reuters, November 29, 2018, <http://reuters.com/article/us-usa-china-students-exclusive/exclusive-fearing-espionage-us-weighs-tighter-rules-on-chinese-students-idUSKCN1NY1HE>.
107. Jenny Leonard and David McLaughlin, "U.S. Presses Ahead on Plan to Limit High-Tech Exports," *Bloomberg*, December 11, 2018, <http://bloomberg.com/news/articles/2018-12-11/u-s-plan-to-limit-high-tech-exports-forges-on-amid-trade-truce>.
108. Ana Swanson, Paul Mozur, and Steve Lohr, "U.S. Blacklists More Chinese Tech Companies Over National Security Concerns," *New York Times*, June 21, 2019, <http://nytimes.com/2019/06/21/us/politics/us-china-trade-blacklist.html>.
109. Jack Stubbs, Joseph Menn, and Chris Bing, "Inside the West's Failed Fight Against China's 'Cloud Hopper' Hackers," Reuters, June 26, 2019, <http://reuters.com/investigates/special-report/china-cyber-cloudhopper>.
110. "Attorney General Jeff Sessions Announces New Initiative to Combat Chinese Economic Espionage," U.S. Department of Justice, November 1, 2018, <http://justice.gov/opa/speech/attorney-general-jeff-sessions-announces-new-initiative-combat-chinese-economic-espionage>.
111. Department of Justice, "Chinese Intelligence Officers and Their Recruited Hackers and Insiders Conspired to Steal Sensitive Commercial Aviation and Technological Data for Years," press release, October 30, 2019, <http://justice.gov/opa/pr/chinese-intelligence-officers-and-their-recruited-hackers-and-insiders-conspired-steal>; "Deputy Attorney General Rod J. Rosenstein Announces Charges Against Chinese Hackers," Department of Justice, December 20, 2018, <http://justice.gov/opa/speech/deputy-attorney-general-rod-j-rosenstein-announces-charges-against-chinese-hackers>; Department of Justice, "PRC State-Owned Company, Taiwan Company, and Three Individuals Charged With Economic Espionage," press release, November 1, 2018, <http://justice.gov/opa/pr/prc-state-owned-company-taiwan-company-and-three-individuals-charged-economic-espionage>.
112. "Innovation Nation: An American Innovation Agenda for 2020," Business Roundtable, January 2019, http://s3.amazonaws.com/brt.org/BRT_Innovation_report_pages_001.pdf.
113. Kenneth Flamm and Qifei Wang, "SEMATECH Revisited: Assessing Consortium Impacts on Semiconductor Industry R&D," in *Securing the Future: Regional and National Programs to Support the Semiconductor Industry*, ed. Charles W. Wessner (Washington, DC: National Academies Press, 2003).
114. Joshua New, "Why the United States Needs a National Artificial Intelligence Strategy and What It Should Look Like," Center for Data Innovation, December 4, 2018, <http://www2.datainnovation.org/2018-national-ai-strategy.pdf>.
115. New, "Why the United States Needs a National Artificial Intelligence Strategy."
116. OPEN Government Data Act of 2016, S.2852, 114th Cong. (2016), <http://congress.gov/bill/114th-congress/senate-bill/2852>.
117. Julia Angwin and Jeff Larson, "Bias in Criminal Risk Scores Is Mathematically Inevitable, Researchers Say," *ProPublica*, December 30, 2016, <http://propublica.org/article/bias-in-criminal-risk-scores-is-mathematically-inevitable-researchers-say>.

118. "Ensuring Long-Term U.S. Leadership in Semiconductors," President's Council of Advisors on Science and Technology, January 2017, http://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_ensuring_long-term_us_leadership_in_semiconductors.pdf.
119. Milo Medin and Gilman Louie, "The 5G Ecosystem: Risks & Opportunities for DoD," Defense Innovation Board, April 3, 2019, http://media.defense.gov/2019/Apr/04/2002109654/-1/-1/0/DIB_5G_STUDY_04.04.19.PDF.
120. Jeremy Hsu, "How the U.S. Can Prepare to Live in China's 5G World," IEEE Spectrum, April 23, 2019, <http://spectrum.ieee.org/tech-talk/telecom/standards/how-america-can-prepare-to-live-in-chinas-5g-world>.
121. Louise Lucas, "Huawei Revenue Rises 39% Despite US Pressure on 5G," *Financial Times*, April 22, 2019, <http://ft.com/content/2cdd5dec-64b6-11e9-9adc-98bf1d35a056>.
122. Medin and Louie, "The 5G Ecosystem: Risks & Opportunities for DoD."
123. Kiran Stacey, "Why Is There No US Rival to Compete With Huawei?" *Financial Times*, April 26, 2019, <http://ft.com/content/18d3823a-65f2-11e9-9adc-98bf1d35a056>.
124. Nicol Turner Lee, "Will the US Be 5G Ready?," *TechTank* (blog), Brookings Institution, July 13, 2018, <http://brookings.edu/blog/techtank/2018/07/13/will-the-us-be-5g-ready>.
125. *Hearing on 5G: The Impact on National Security, Intellectual Property, and Competition: Statement Before the Senate Committee on the Judiciary*, 116th Cong. (2019) (statement of Dr. Charles Clancy, Bradley Professor of Cybersecurity, Virginia Tech), <http://judiciary.senate.gov/imo/media/doc/Clancy%20Testimony.pdf>.
126. Ryan McMorow, "Huawei a Key Beneficiary of China Subsidies That US Wants Ended," *Phys.org*, May 30, 2019, <http://phys.org/news/2019-05-huawei-key-beneficiary-china-subsidies.html>.
127. Lenka Ponilkeska, "Countries Seek United 5G Security Approach Amid Huawei Concerns," *Bloomberg*, May 3, 2019, <http://bloomberg.com/news/articles/2019-05-03/countries-seek-united-5g-security-approach-amid-huawei-concerns>.
128. Stephen Castle, "Pompeo Attacks China and Warns Britain Over Huawei Security Risks," *New York Times*, May 8, 2019, <http://nytimes.com/2019/05/08/technology/pompeo-huawei-britain.html>.
129. Medin and Louie, "The 5G Ecosystem: Risks & Opportunities for DoD."
130. *Times Higher Education*, "World University Rankings 2019 by Subject: Engineering and Technology," http://timeshighereducation.com/world-university-rankings/2019/subject-ranking/engineering-and-IT#!page/0/length/25/sort_by/rank/sort_order/asc/cols/stats.
131. Jeff Stone, "Corporate Giants Want to Help Students, Feds and Themselves by Offering Cyber Pros \$75,000 in Loan Assistance," *Cyberscoop*, April 10, 2019, <http://cyberscoop.com/workforce-cyber-talent-initiative-loan-assistance>.
132. Yangyang Cheng, "Don't Close the Door on Chinese Scientists Like Me," *Foreign Policy*, June 4, 2018, <http://foreignpolicy.com/2018/06/04/dont-close-the-door-on-chinese-scientists-like-me>.

133. "National Policy on the Transfer of Scientific, Technical, and Engineering Information," National Security Decision Directives (Federation of American Scientists, September 21, 1985), <http://fas.org/irp/offdocs/nsdd/nsdd-189.htm>.
134. Secretary of the Air Force Public Affairs, "\$40M Available for Start-Ups, Small Businesses Through Air Force Pitch Day," Air Force Materiel Command, January 15, 2019, <http://afmc.af.mil/News/Article-Display/Article/1732301/40m-available-for-start-ups-small-businesses-through-air-force-pitch-day>.
135. "Mobilizing Tech Talent," Partnership for Public Service, September 18, 2018, http://ourpublicservice.org/wp-content/uploads/2018/09/Mobilizing_Tech_Talent-2018.09.26.pdf.
136. Mark Hagerott and James Stravridis, "Trump's Big Defense Buildup Should Include a National Cyber Academy," *Foreign Policy*, March 21, 2017, <http://foreignpolicy.com/2017/03/21/trumps-big-defense-buildup-should-include-a-national-cyber-academy-military-education>.
137. Amy Zegart and Kevin Childs, "The Divide Between Silicon Valley and Washington Is a National-Security Threat," *Atlantic*, December 13, 2018, <http://theatlantic.com/ideas/archive/2018/12/growing-gulf-between-silicon-valley-and-washington/577963>.
138. Exec. Order No. 13875, 84, C.F.R. 28711 (2019), <http://whitehouse.gov/presidential-actions/executive-order-evaluating-improving-utility-federal-advisory-committees>.
139. Joel Meyer, "Startups Should Love Government Work," *Defense One*, February 8, 2019, <http://defenseone.com/ideas/2019/02/startups-should-love-government-work/154722/?oref=d-channeltop>.
140. Stephen Ezell and Caleb Foote, "How Stringent Export Controls on Emerging Technologies Would Harm the U.S. Economy," Information Technology and Innovation Foundation, May 20, 2019, <http://itif.org/publications/2019/05/20/how-stringent-export-controls-emerging-technologies-would-harm-us-economy>.
141. Cade Metz, "Curbs on A.I. Exports? Silicon Valley Fears Losing Its Edge," *New York Times*, January 1, 2019, <http://nytimes.com/2019/01/01/technology/artificial-intelligence-export-restrictions.html>.
142. A Bill to Establish the Office of Critical Technologies and Security, and for Other Purposes, S.29, 116th Cong. (2019), <http://congress.gov/bill/116th-congress/senate-bill/29>.
143. Securing American Science and Technology Act of 2019, H.R. 3038, 116th Cong. (2019), <https://www.congress.gov/116/bills/hr3038/BILLS-116hr3038ih.pdf>.
144. James Manyika, Susan Lund, Marc Singer, Olivia White, and Chris Berry, "How Digital Finance Could Boost Growth in Emerging Economies," McKinsey Global Institute, September 2016, <http://mckinsey.com/featured-insights/employment-and-growth/how-digital-finance-could-boost-growth-in-emerging-economies>.
145. Nigel Cory, "Cross-Border Data Flows: Where Are the Barriers, and What Do They Cost?," Information Technology and Innovation Foundation, May 1, 2017, <http://itif.org/publications/2017/05/01/cross-border-data-flows-where-are-barriers-and-what-do-they-cost>.
146. Samm Sacks and Manyi Kathy Li, "How Chinese Cybersecurity Standards Impact

- Doing Business in China,” Center for Strategic and International Studies, August 2, 2018, <http://csis.org/analysis/how-chinese-cybersecurity-standards-impact-doing-business-china>.
147. Hilary McGeachy, “U.S.-China Technology Competition: Impacting a Rules-Based Order,” May 2, 2019, United States Studies Centre, University of Sydney, <http://ussc.edu.au/analysis/us-china-technology-competition-impacting-a-rules-based-order>.
148. Lee G. Branstetter, Britta Glennon, and J. Bradford Jensen, “The Rise of Global Innovation by US Multinationals Poses Risks and Opportunities,” Peterson Institute for International Economics, June 2019, <http://piie.com/research/piie-charts/us-multinational-corporations-have-shifted-foreign-rd-towards-nontraditional>.
149. *International Science and Technology Cooperation: Statement Before the Subcomm. on Research and Science Education*, 110th Cong. (2008) (statement of Dr. Nina V. Federoff, Science and Technology Advisor to the Secretary of State).
150. Daniel Kliman and Brendan Thomas Noone, “How the Five Eyes Can Harness Commercial Innovation,” *DefenseOne*, June 25, 2018, <http://defenseone.com/ideas/2018/07/how-five-eyes-can-harness-commercial-innovation/150040>.
151. U.S. Department of Energy, *75 Breakthroughs by the U.S. Department of Energy’s National Laboratories* (Livermore, CA: Lawrence Livermore National Laboratory Public Affairs Office, 2017), <http://energy.gov/downloads/75-breakthroughs-americas-national-laboratories>.
152. Philip Rossetti, “Publicly Funded National Labs Important to U.S. Innovation,” American Action Forum, February 14, 2018, <http://americanactionforum.org/research/publicly-funded-national-labs-still-important-u-s-innovation>.
153. Task Force on U.S.-China Policy, Orville Schell and Susan L. Shirk, ed., *Course Correction: Toward an Effective and Sustainable China Policy*.