COUNCIL on FOREIGN RELATIONS

December 12, 2017

Chinese Technology Development and Acquisition Strategy and the U.S Response

Prepared statement by

Adam Segal

Ira A. Lipman Chair in Emerging Technologies and National Security and Director of the Digital and Cyberspace Policy Program

Council on Foreign Relations

Before the

House Committee on Financial Services,

Monetary Policy and Trade Subcommittee

United States House of Representatives

1st Session, *115*th Congress

Hearing on Examining the Operations of the Committee on Foreign Investment in the United States (CFIUS)

Introduction

Chairman Barr, Ranking Member Moore, and members of the committee, thank you for the opportunity to testify on this important subject.

While the openness of U.S markets and science and technology (S&T) system is central to economic and national security, it is also a threat to those same interests. China in particular has benefited from access to U.S. universities, companies, and markets, and the diffusion of technologies and knowledge from the United States and other advanced economies has played a role in the acceleration of the modernization of the People's Liberation Army.

The challenge for policy makers is twofold. First, China's strategy to develop, acquire, and diffuse technology for economic and security interests is multifaceted involving investments in research and development, industrial policy, protection of intellectual property, talent development, and foreign acquisitions. The U.S. response therefore must be similarly broad. Any policy, say reform of the Committee on Foreign Investment in the United States (CFIUS) or export control laws, is necessary but not sufficient, and the United State must also address Chinese techno-nationalism more broadly.

Second, policy makers must adopt measures to block the flow of critical technologies to potential adversaries while not inflicting self-harm. While there are tight links between economic and national security, policies should be narrowly focused on preventing the acquisition of technologies that would threaten the U.S. military edge, not broader economic competitiveness writ large. This is made more difficult by three factors: globalization of science and technology; the tight integration of the U.S. and Chinese S&T systems; and the dual-use nature of many frontier technologies, especially artificial intelligence (AI).

China's science and technology strategy

The United States is still the world leader in science and technology, but others are increasing their capabilities rapidly. A report from the UK Royal Society describes the situation as an "increasingly multipolar scientific world, in which the distribution of scientific activity is concentrated in a number of widely dispersed hubs."[1] Middle income countries—including India, Brazil, and China—have expanded their expenditures on R&D, increasing their contribution to world R&D spending from 40.8 percent in 2007 to 47.3 percent in 2013.[2]

China's goals in science and technology are particularly noteworthy. The 2006 National Medium- and Long-Term Plan for the Development of Science and Technology states China's goal of becoming an "innovative nation" by 2020 and a "global scientific power" by 2050.[3] Beijing sees technological innovation as central to ensuring that China does not remain the factory of the world and moves up the value chain—that it shifts from "made in China" to "invented in China." Chinese policy makers also have a long history of techno-nationalism and want to reduce their technological dependence on advanced economies, especially the United States and Japan. In addition, the Chinese leadership sees a tight link between technological and military strength. In an address to military delegates at the March 2017 meeting of the People's Congress, President Xi Jinping noted that science and technology were "key to military upgrading" and called for "a greater sense of urgency to push for science and technology innovation."[4]

China's investment in R&D has grown by 20 percent a year since 1999.[5] R&D spending is now approximately $233 billion, 2.1 percent of GDP, and 20 percent of total world R&D expenditure.[6] China is also now the world's largest producer of undergraduates with science and engineering degrees, and Chinese scientists are writing a large number of scientific papers, a growing number of which are well-cited. In 1996, the United States published more than ten times as many scientific research papers as China. China is now the second largest producer of scientific papers after the United States, and has shown large gains in computer science, engineering, and AI. Ethnic Chinese authors, for example, account for 43 percent of the top 100 AI journals and conferences.[7]

Science and technology is front and center in the 13th Five-Year Plan (2016-2020). Science and technology development is discussed first in the plan and for longer than any other subject.[8] This broad plan is being fleshed out through industrial policies designed to raise China's innovation capabilities, three of the most important being: an attempt to build an indigenous semiconductor industry; "Made in China 2025"; and the "Next-Generation Artificial Intelligence Development Plan." All are strategic initiatives aimed at facilitating China's dominance in various high-tech spaces.

China's 2014 "IC Promotion Guidelines" involves new backing for semiconductors, with reported investments between $100 and $150 billion in public and private funds. The goal is to close the gap with other countries in the design, fabrication and packaging of chips of all types by 2030; to have Chines firms produce 70 percent of the chips consumed by Chinese industry; and to end dependence on foreign supplies. Policy makers have likened Chinese dependence on foreign chips to its need for foreign oil; China imported $228 billion of integrated circuits in 2016. The government provides capital subsidies to domestic firms, and to foreign firms who locate in China, as well as encourages domestic consumers to purchase only from Chinese suppliers.

"Made in China 2025" sets out ambitious targets for upgrading China's aging manufacturing base through smart manufacturing. This includes integrating automation, smart sensors, and Internet of Things (IoT) devices into Chinese industry. Borrowing from Germany's 'Industry 4.0,' China sees an opportunity to use industrial policies to dominate high value-added industrial sectors like aviation, integrated circuits, next-generation information technology, robotics, new energy vehicles, and biopharmaceuticals. The plan offers low-interest loans from state-owned investment funds and development banks; assistance in buying foreign competitors; and extensive research subsidies.[9]

China's "Next-Generation Artificial Intelligence Development Plan" provides a roadmap for China to dominate the emerging artificial intelligence space and encourage broad adoption of AI across the economy and society. China currently trails the U.S. in terms of producing top-rated AI research and patents. But China has at least three advantages: huge data sets; a permissive regulatory environment with very little concern for privacy; and significant government support and investment.

The Next-Generation Artificial Intelligence Development Plan" aims to turn China's AI industry into a "world leader' worth RMB 400 billion ($60 billion) by 2025 and a 'premier innovation center' worth RMB 1 trillion by 2030 ($150 billion). So far, China's Ministry of Science and Technology has established an AI advisory committee with a mix of state scientists and private sector leaders and has enlisted China's largest tech companies to join an 'AI national team' and build "open innovation platforms" for several applications of AI.[10] Cooperation with private companies is a prominent part of China's AI push, with several Chinese companies designated as national champions to close the gap between China and the U.S. In February2017, the National Development and Reform Commission commissioned Baidu to build a national laboratory for deep learning in partnership with two Chinese universities.[11]

Inward investment regime

Access to the Chinese market has often been predicated on the transfer of technologies. Foreign firms are often pressured to license technology to Chinese partners or establish R&D centers within China. General Motors, for example, was reportedly precluded from receiving purchase subsidies for the Volt, its electric hybrid car, until it transferred engineering knowledge from its three main technologies (electric motors, complex electronic controls, and power storage devices) to a joint venture with a Chinese automaker.[12] In April 2010, Beijing ordered high-tech companies to turn over the encryption codes to their smart cards, Internet routers, and other technology products in order to be included in the government procurement catalog.[13] Firms are also often forced into joint ventures, frequently with state-owned actors. These partnerships regularly result in inadvertent technology transfer as engineers and managers work together, or more directly from the outright theft of intellectual property.

China's longstanding willingness to turn a blind eye to intellectual property theft has also resulted in widespread technology transfer. The problem has been especially prominent in software, where Microsoft estimates that 95 percent of its Office software and 80 percent of Windows operating system operating in China are pirated. 80 percent of Chinese government agencies are suspected of running illegal copies of Microsoft and other foreign software.[14] While the enforcement of IP law has recently improved, over the long term Chinese firms benefited from not having to invest in their own R&D and not paying licensing or royalty fees.

Foreign acquisitions

While China's innovation strategy emphasizes "indigenous innovation", it also encourages Chinese companies to acquire core technologies and know-how abroad as a means of catching up or leapfrogging the competition. There are a number of channels, both legal and illegal, for Beijing to acquire new technology.

Foreign purchases have played a large role in the semiconductor strategy. Chinese investment in the United States in 2016 was $45.6 billion, and Chinese firms have, according to estimates from the Rhodium Group, made about $34 billion in bids for U.S. semiconductor companies since 2015.[15] Tsinghua Unigroup emerged from relative obscurity to purchase two Chinese firms for $2.6 billion. It bought a 51 percent stake in H3C, a Hong Kong subsidiary of Hewlett-Packard that makes data-networking equipment, for $2.3 billion. Bids for Micron, a big American maker of DRAM (type memory chips used to store data on desktop computers and servers), SK Hynix, a South Korean DRAM manufacturer, and Western Digital failed because of political opposition.[16] Other Chinese entities have also faced political opposition. In 2016, CFIUS rejected the sale of Aixtron SE of Germany to China's Fujian Grand Chip Investment Fund. In September 2017, President Trump blocked Canyon Bridge Capital Partners LLC, a China-backed buyout fund, from acquiring Lattice Semiconductor Corp for $1.3 billion.

In other instances, China has purchased portions of large semiconductor companies, perhaps to stay under the threshold for investigation. Jianguang Asset Management Co. Ltd. (JAC Capital), for example, bought NXP's RF Power business for $1.8 billion.[17] The sources of Chinese investment are opaque. Unigroup, a commercial entity spun off from Tsinghua University, appears to receive significant financial support from the government. The owner of Fujian Grand Chip Investment Fund, for example, is a private businessperson, Liu Zhendong. But Sino IC Leasing, a subsidiary of the National IC Fund, offered to provide a loan of 500 million to make the Aixtron deal possible. Moreover, in the months before Aixtron sought new investors, its share price tumbled after Fujian-based San'an Optoelectronics cancelled a large order of machines in late 2015. A report from the Mercator Institute of China Studies suggests a close relations between San'an, Fujian Grand Chip, and the National IC Fund. The parent company of San'an

Optoelectronics, the San'an group, owns shares in Sino IC Leasing.[18] This lack of transparency makes it difficult to differentiate between economic and strategic motivations for a purchase.

In the face of this growing scrutiny, Chinese entities appear to be pursuing other means of acquiring technology in order to circumvent oversight. According to a 2017 report from the Defense Innovation Unit Experimental, China is participating in an increasing number of venture deals, about 10 percent of all venture deals in 2015 up from a 5 percent average participation rate during 2010-2016. Beijing is especially active in the areas of artificial intelligence, autonomous vehicles, augmented/virtual reality, robotics, and blockchain technology.

Baidu, for example, is partnering with Comet Labs, a San Francisco-based fund specializing in machine intelligence. In August 2016, Baidu and Ford jointly invested $150 million in Velodyne, a maker of LiDAR sensors, which are an important component of self-driving car technology. The company began developing sensors for driverless cars after participating in a DARPA competition in 2005 and has since sold its technology to the Navy for unmanned surface vehicles.[19] In April 2016, state-backed Haiyin Capital made a minority investment in Neurala, which is developing AI technology that can automate self-driving cars, robots, and drones.[20] According to the *New York Times*, Neurala's CEO had been in talks with the U.S. Air Force about a partnership, but grew frustrated by the slow pace at which talks progressed. A report from Defense Group Inc. stated that Huiyin's investment in Neurala creates uncertainty over China's access to the company's source code and whether Neurala's technology is secure for U.S. end-users. [21]

Cyber and industrial espionage

China also acquires foreign technology through cyber and industrial espionage. During this decade, Google, Nasdaq, DuPont, Johnson & Johnson, General Electric, RSA, and at least a dozen others have had proprietary information stolen by Chinese-based hackers. A 2013 private commission, chaired by Dennis Blair, former director of national intelligence, and Jon Huntsman, former ambassador to China, argued that the annual "losses are likely to be comparable to the current annual level of U.S. exports to Asia—$300 billion." Cybersecurity companies noted a significant decline in Chinese activity after the 2015 agreement between President Obama and President Xi, in which both sides agreed not to hack each other's private companies for commercial gain. Recent reporting suggests, however, that China is pushing the envelope, going after technologies that are dual-use, and so might not be covered by the agreement, as well as some civil society groups.

In the physical world, Chinese nationals have been charged in the theft of radiation-hardened microchips, precision navigation devices, the processes for high-volume manufacturing of chips used to light and electrify flat-screen TVs and smartphones, and other technologies. In addition, according to a recent report for the U.S.-China Economic and Security Review Commission, the theft of American technology is often conducted through China's science and technology institutes and industrial enterprises. [22] The "key modality is no longer the spy," according to Jim Richberg, former deputy national counterintelligence executive, "but the businessman, student, or academic." [23]

National security implications

Science and technology diffusion has and will continue to improve Chinese military capabilities. Shifting research centers to China and developing collaborative business relations with Chinese companies involves

American institutions in the diffusion process, inadvertently speeding Beijing's military modernization. In China, the shipping and telecommunications sectors have made steady improvements in R&D and production through their engagement with the international economy and these technological capacities have been converted into new military capabilities.[24] The 2011 report from the U.S.-China Economic and Security Review Commission argues that U.S. aerospace companies may have unknowingly assisted Chinese military modernization.

The newest wave of Chinese investment in sensitive technologies such as robotics, AI, and sensors is a further threat to the U.S. technological edge. Some of these technologies will inevitably end up in the hands of enterprises and universities with tight links to the PLA. Moreover, Chinese investment in high-tech firms could prevent U.S. government or military investment and cooperation with those same companies.[25]

In addition, Chinese leaders are intent on building a system that allows the military to take advantages of gains in the civilian economy. Civil-military fusion [军民融合 *junmin ronghe*] is a pillar of Chinese military modernization and an effort to bolster the country's innovation system for advanced dual-use technologies in industries like aviation, aerospace, and information technology. Introduced by former President Hu Jintao in 2009, the effort to bridge the gap between the civilian industrial base and the military has intensified under President Xi Jinping. Within his first year in office, the Central Committee voted to elevate civil-military fusion to a national strategy, and in January 2017 Xi created the Central Commission for Integrated Military and Civilian Development, a new high-level decision making and coordination body for civil-military fusion efforts.[26]

Civil-military fusion plays a prominent role in both "Made in China 2025" and the "Next-Generation Artificial Intelligence Development Plan." Emerging technology like AI, drones, robotics, and big data are already blurring the line between technology intended for military and commercial purposes; China's strategy has been to treat military and commercial technological developments as two-sides of the same coin. For example, prominent AI researchers like Le Deyi, who is the head of the China Association for Artificial Intelligence, participate in research with commercial enterprises and hold rank in the People's Liberation Army.

Policy challenges

Any attempt to prevent technology flowing to China and improving military capabilities is complicated by at least three factors. First, as noted above, innovation is increasingly global, and there are few technologies that the U.S. monopolizes. Even in artificial intelligence, which seems to be shaping up as a two-way race between the United States and China, there are clusters of excellence in the UK, Canada, and Israel. Any U.S policy will have to be sensitive to the fact that there are other sources of technology.

Second, the border between "American" and "Chinese" science and technology is no longer as sharp as international R&D networks and business collaborations expand. China-based scholars, for example, choose to coauthor with U.S. colleagues more frequently with those from other countries; nearly 40 percent of China's science and engineering publications in international journals had U.S.-based coauthors. The information technology sector is particularly interconnected, stretching across the Pacific and involving Chinese, American, and Taiwanese entrepreneurs, designers, managers, and technicians. Research and development in AI is likely to replicate this pattern. A number of high profile researchers like Andrew Ng have moved from U.S. universities and companies to Chinese firms and then back again. As a result of this interconnection, policies designed to prevent the flow of technology or people could have a negative impact on U.S. capabilities.

Finally, the list of purely military technologies that the United States can control has become very narrow. Most of the technologies underlying the AI and robotics revolutions will be dual use. There is, for example, likely very little to distinguish the technology in a self-driving car and a self-driving tank.

Policy recommendations

Given these challenges, three principles should guide U.S. policy making.

First, CFIUS reform should be small part of the U.S. response to Chinese technology development and acquisition. Trade efforts to combat techno-nationalism and remove coercive policies to transfer technology are especially important tools to prevent the uncontrolled diffusion of technology and knowledge to Beijing. A great deal of technology transfer happens under the threshold of CFIUS (or export controls) but under pressure from and in return for market access to China.

In addition, some of the worry about China's rise as a science and technology power is compounded by a fear that the United States has been distracted, neglecting science and underfunding basic research. Several top science posts in the White House remain vacant. The president's budget request includes significant cuts of the budgets of the National Science Foundation, National Institute of Health, and Environmental Protection Agency, and the new tax law has a negative impact on science, taxing tuition waivers used by graduate students in science, technology, and mathematics.

Second, unilateral action will be of limited use. China is expanding its science and technology partnerships with Europe, Israel, India and others. Unless Washington and its friends agree to a similar set of technologies to control, Beijing will easily elude U.S. policy. Past attempts to control dual-use technologies do not provide a great deal confidence, however, that the United States and its partners can create an effective framework for the next generation of innovation.

Third, for any reform effort to succeed, CFIUS will require greater capacity. It will need more capacity to handle new investigations on top of what is already a large volume of cases. It will need more capacity to discern the sources of Chinese investment—who is behind an investment and if the motivation is economic, strategic, or some combination. It will also need new mechanisms to tap into academic and commercial expertise to better understand the development trajectories of frontier technologies and what their relationship to military capacity may be.

[1] "Knowledge, networks and nations: global scientific collaboration in the twenty first century" (Royal Society, London, March 2011) available: http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2011/4294976134.pdf.

[2] "UNESCO Science Report: Towards 2030," (UNESCO Publishing: 2016), https://en.unesco.org/unesco_science_report.

[3] "The National Medium- and Long-Term Plan for the Development of Science and Technology (2006-2020)," *State Council*, People's Republic of China, https://www.itu.int/en/ITU-D/Cybersecurity/Documents/National_Strategies_Repository/China_2006.pdf.

4 "China's Xi pushes advanced technology for military," *Reuters*, March 12, 2017 https://www.reuters.com/article/us-china-parliament-defence/chinas-xi-pushes-advanced-technology-for-military-idUSKBN16K02V.

5 Gautam Naik, "China Surpasses Japan in R&D as Powers Shift," *Wall Street Journal*, December 10, 2010, https://www.wsj.com/articles/SB10001424052748703734204576019713917682354.

6 Reinhilde Veugelers, "China is the world's new science and technology powerhouse," *Bruegel*, August 30, 2017, http://bruegel.org/2017/08/china-is-the-worlds-new-science-and-technology-powerhouse/.

7 Kai-Fu Lee and Paul Triolo, "China's Artificial Intelligence Revolution: Understanding Beijing's Structural Advantage," *Eurasia Group,* December 2017, https://www.eurasiagroup.net/files/upload/China_Embraces_AI.pdf.

8 Scott Kennedy and Christopher K. Johnson, "Perfecting China, Inc.: The 13th Five-Year Plan," *Center for Strategic and International Studies*, May 2016, https://csis-prod.s3.amazonaws.com/s3fs-public/publication/160521_Kennedy_PerfectingChinaInc_Web.pdf.

9 Keith Bradsher and Paul Mozur, "China's Plan to Build Its Own High-Tech Industries Worries Western Businesses," *New York Times*, March 7, 2017 https://www.nytimes.com/2017/03/07/business/china-trade-manufacturing-europe.html

10 "China recruits Baidu, Alibaba and Tencent to AI 'national team,'" *South China Morning Post,* November 21, 2017, http://www.scmp.com/tech/china-tech/article/2120913/china-recruits-baidu-alibaba-and-tencent-ai-national-team.

11 "China's first 'deep learning lab' intensifies challenge to US in artificial intelligence race," *South China Morning Post*, February 21, 2017, http://www.scmp.com/tech/china-tech/article/2072692/chinas-first-deep-learning-lab-intensifies-challenge-us-artificial.

12 Robert D. Atkinson, "Enough is Enough: Confronting Chinese Innovation Mercantilism," *The Information Technology & Innovation Foundation*, February 2012, http://www2.itif.org/2012-enough-enough-chinese-mercantilism.pdf?_ga=2.80672215.1914708704.1513087866-1294095666.1513087866.

13 Adam Segal, "China's Innovation Wall: Beijing's Push for Homegrown Technology," *Foreign Affairs*, September 28, 2010, http://www.foreignaffairs.com/articles/66753/adam-segal/chinas-innovation-wall.

14 Enough is Enough: Confronting Chinese Innovation Mercantilism

15 Bob Davis and Eva Dou, "China's Next Target: U.S. Microchip Hegemony," *Wall Street Journal*, July 27, 2017, https://www.wsj.com/articles/chinas-next-target-u-s-microchip-hegemony-1501168303.

16 "Chips on their shoulders," *The Economist,* January 23, 2016, https://www.economist.com/news/business/21688871-china-wants-become-superpower-semiconductors-and-plans-spend-colossal-sums.

17 Junko Yoshida, Lurking Behind Every M&A Is China, *EE Times*, December 13, 2016, https://www.eetimes.com/document.asp?doc_id=1330969.

18 "Made in China: The making of a high-tech superpower and consequences for industrial countries," *Mercator Institute for China Studies*, December 2016, https://www.merics.org/fileadmin/user_upload/downloads/MPOC/MPOC_Made_in_China_2025/MPOC_No.2_MadeinChina_2025.pdf.

19 Evan Ackerman, "Ford and Baidu Invest $150 Million in Velodyne for Affordable Lidar for Self-Driving Cars," *IEEE Spectrum*, August 17, 2016, https://spectrum.ieee.org/cars-that-think/transportation/sensors/ford-and-baidu-invest-150-million-in-velodyne-for-affordable-automotive-lidar; Paul Mozur and Jane Perlez, "China Tech Investment Flying Under the Radar, Pentagon Warns," New York Times, April 7, 2017, https://www.nytimes.com/2017/04/07/business/china-defense-start-ups-pentagon-technology.html?_r=1.

20 Hiawatha Bray, "Boston firm's artificial intelligence technology may have broader applications," Boston Globe, August 14, 2017, https://www.bostonglobe.com/business/2017/08/14/boston-startup-builds-mobile-brains/CJcreJWZRv0caynAK1DWO/story.html.

21 Defense Group Inc. "China's Industrial and Military Robotics Development," *U.S.-China Economic and Security Review Commission*, October 2016, Pg, 105, available at:

https://www.uscc.gov/sites/default/files/Research/DGI_China%27s%20Industrial%20and%20Military%20Robotics%20Development.pdf.

[22] "China's Program for Science and Technology Modernization: Implications for American Competitiveness," Prepared for The U.S.-China Economic and Security Review Commission, January 2011, https://www.uscc.gov/Research/china%E2%80%99s-program-science-and-technology-modernization-implications-american-competitiveness.

[23] Jim Richberg, "The Counterintelligence Implications of Deemed Export Control," Workshop on the Globalization of the University and Deemed Export Policy, Oak Ridge Center for Advanced Studies, March 6–7, 2006.

[24] Evan S. Medeiros, Roger Cliff, Keith Crane, James C. Mulvenon, "A New Direction for China's Defense Industry," *RAND*, https://www.rand.org/pubs/monographs/MG334.html.

[25] Chinese Investment in Critical U.S. Technology: Risks to U.S. Security Interests: Insights from a CFR Workshop, October 16, 2017, https://www.cfr.org/report/chinese-investment-critical-us-technology-risks-us-security-interests

[26] Xi to head central commission for integrated military, civilian development," *Xinhua*, January 22, 2017, http://news.xinhuanet.com/english/2017-01/22/c_136004750.htm.