



Defense Innovation Unit Experimental (DIUx)

China's Technology Transfer Strategy:

How Chinese Investments in Emerging Technology Enable A Strategic Competitor to Access the Crown Jewels of U.S. Innovation

Updated with 2016 and 2017 Data

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Executive Summary

This report explores China's participation in venture deals¹ financing early-stage technology companies to assess: how large the overall investment is, whether it is growing, and what technologies are the focus of investment. **Chinese participation in venture-backed startups is at a record level of 10-16% of all venture deals (2015-2017)** and has grown quite rapidly in the past seven years. The technologies where China is investing are the same ones where U.S. firms are investing and that will be foundational to future innovation: artificial intelligence, autonomous vehicles, augmented/virtual reality, robotics and blockchain technology. Moreover, these are some of the same technologies of interest to the U.S. Defense Department to build on the technological superiority of the U.S. military today. The rapidity at which dual-use technologies are developed in the commercial sector has significant impact on the nature of warfare; mastering them ahead of competitors will "ensure that we will be able win the wars of the future".²

Because the U.S. economy is open, foreign investors, including those from China, are able to invest in the newest and most relevant technologies gaining experience with those technologies at the same rate as the U.S. does. The U.S. government does not currently monitor or restrict venture investing nor the potential transfer of early-stage technology. The primary tool the government has to block or mitigate foreign investment is the Committee on Foreign Investment in the United States (CFIUS); however, since CFIUS reviews specific deals on a case-by-case basis (rather than systematic assessments of acquisitions or acquirers) and only deals that involve a controlling interest by foreign investors (usually mergers and acquisitions), CFIUS is only partially effective in protecting national security since its jurisdiction is limited. The other principal tool to inhibit technology transfer is the U.S. export control regime. Export controls are effective at deterring exports of products to undesirable countries and can be used to prevent the loss of advanced technologies but controls were not designed to govern early-stage technologies or investment activity. Importantly, to be effective, export controls require collaboration with international allies, a long process where cooperation is not assured.

Further, venture investing is only a small part of China's investment in the U.S.--which includes all forms of investment and investor types. Investing is itself only a piece of a larger story of massive technology transfer from the U.S. to China which has been ongoing for decades. This report places venture investing within the larger context of China's long-term, systematic effort to attain global leadership in many industries, partly by transferring leading edge technologies from around the world.

U.S. military superiority since World War II has relied on both U.S. economic scale and technological superiority. U.S. technological pre-eminence enabled the series of offset strategies which included being first with nuclear weapons (the First Offset) and the electronics-enabled weapons of night vision, laser-guided bombs, stealth and jamming technologies as well as space-based military communications and navigation enabling the U.S. to dominate the battlefield (the Second Offset). Much of this technology came from research sponsored by the U.S. government and

¹ A venture deal is a financing that provides startup or growth equity capital provided by private investors, usually venture capitalists.

² The 2018 National Defense Strategy recognizes the critical role of technology development in the commercial sector for national security purposes: "The drive to develop new technologies is relentless, expanding to more actors with lower barriers of entry, and moving at accelerating speed. New technologies include advanced computing, "big data" analytics, artificial intelligence, autonomy, robotics, directed energy, hypersonics, and biotechnology—the very technologies that ensure we will be able to fight and win the wars of the future. The fact that many technological developments will come from the commercial sector means that state competitors and non-state actors will also have access to them, a fact that risks eroding the conventional overmatch to which our nation has grown accustomed. Maintaining the department's technological advantage will require changes to industry culture, investment sources, and protection across the National Security Innovation Base." p. 3



the Defense Department specifically. However, the technologies which will create the Third Offset are to a large extent being developed by early-stage technology companies with significant commercial markets. If we allow China access to these same technologies concurrently, then not only may we lose our technological superiority but we may even be facilitating China's technological superiority.

That China will grow to be an economy as large as ours may be inevitable; that we aid their mercantilist strategy through free trade and open investment in our technology sector is a choice. As a result, while strategic competition³ with China is a long-term threat rather than a short-term crisis, preserving our technological superiority and economic capacity are important issues for national focus today.

Key Points

- China is executing a multi-decade plan to transfer technology to increase the size and value-add of its economy, currently the world's 2nd largest. By 2050, China may be 150% the size of the U.S.⁴ and decrease U.S. relevance globally⁵.
- Technology transfer to China occurs in part through increasing levels of investment and acquisitions of U.S. companies. **China participated in ~16% of all venture deals in 2015 up from 6% average participation rate during 2010-2015.**
- **China is investing in the critical future technologies that will be foundational for future innovations both for commercial and military applications: artificial intelligence, robotics, autonomous vehicles, augmented and virtual reality, financial technology and gene editing.** The line demarcating products designed for commercial vs. military purposes is blurring with these new technologies.
- Investments are only one means of technology transfer, which also occurs through the following licit and illicit vehicles where the cost of stolen intellectual property has been estimated at \$300 billion per year.⁶
 - Industrial espionage, where China is by far the most aggressive country operating in the U.S.
 - Cyber theft on a massive scale deploying hundreds of thousands of Chinese army professionals
 - Academia, since 25% of U.S. STEM graduate students are Chinese foreign nationals
 - China's use of open source information cataloguing foreign innovation on a large scale
 - Chinese-based technology transfer organizations
 - U.S.-based associations sponsored by the Chinese government to recruit talent
 - Technical expertise on how to do deals learned from U.S. firms.
- China's goals are to be #1 in global market share in key industries, to reduce reliance on foreign technology and to foster indigenous innovation. Through published documents such as Five-Year Plans and Made in China 2025, China's industrial policy is clear in its aims of import substitution and technology innovation.
- There are several examples of Chinese indigenous innovation where China is doing much more than copying technology.
- **The U.S. does not have a comprehensive policy or the tools to address this massive technology transfer to China.** CFIUS is one of the only tools in place today to govern foreign



investments but it was not designed to protect sensitive technologies. CFIUS is only partially effective in protecting national security given its limited jurisdiction.

- **The U.S. government does not have a holistic view of how fast this technology transfer is occurring, the level of Chinese investment in U.S. technology, or what technologies we should be protecting.**
- DoD has several specific areas of risk resulting from the scale of China's investments and its technology transfer:
 - Supply chains for U.S. military equipment and services are increasingly owned by Chinese firms.

- China's targeted investments to close the gap in capabilities between its military and the U.S. military.
- Industrial espionage and cyber theft mean key defense designs and plans are in Chinese hands.
- There is no agreed upon list of technologies to protect for the future though an effort exists today to delineate technologies critical to current acquisition programs (JAPEC⁷).

³ As discussed in the summary of the 2018 National Defense Strategy, the central challenge to U.S. prosperity and security is the "reemergence of long-term strategic competition" by revisionist powers such as China and Russia.

⁴ According to The Economist, U.S. GDP will be \$70 trillion by 2050 and China's GDP will be \$105 trillion. "Long Term Macroeconomic Forecasts--Key Trends to 2050," The Economist Intelligence Unit (2015).

⁵ The U.S. has not competed with an economic rival that could be larger than its own economy in 150 years.

⁶ "The IP Commission Report: The Report on the Theft of American Intellectual Property," National Bureau of Asian Research (May, 2013). Retrieved at <http://www.ipcommission.org>

⁷ Joint Acquisition Protection & Exploitation Cell, described on p. 12 of this paper.

China's Growing Investment in the U.S. & in U.S. Technology

China's Global and U.S. Investment

China's global foreign direct investment (FDI) is growing rapidly and is at a record level in a range of \$200-250 billion, with \$213 billion in announced acquisitions in 2016.^{8,9} China's FDI investment in the U.S. in 2016 was \$45.6 billion and cumulative FDI in the U.S. since 2000 now exceeds \$100 billion.¹⁰ China's investment stems from a variety of motivations. As China's economy has grown to the world's second largest, there is a commercial interest in expanding to other markets as well as a motivation for companies and individuals to diversify their investments geographically and politically as well as hedge against currency fluctuations. With the recent concerns about devaluation of the currency relative to the U.S. dollar and concerns about the underlying economic fundamentals, Chinese investors have made more investments overseas and this has led to an increased level of capital controls.¹¹



China's U.S. Technology Investment

China's total investment in U.S. technology (electronics, information and communications technology, biotech and energy) for the past decade, 2006-2016, totaled \$35 billion and in 2016 was about \$8.5B.¹² Since the U.S. is a global leader of technological innovation, it is logical that China would seek to make increasing investments in U.S. technology companies. While it is likely that China's investment in technology is driven in part by commercial interests, it is unlikely this is the sole reason given China's explicit technology goals. Investment is one of the means for China to accomplish its technology transfer goals.¹³ Both these goals and China's multiple vehicles for technology transfer are described later.

China's U.S. Early-Stage Technology Investment

Chinese investment activity in early stage technology deals is also growing rapidly and peaked in 2015 with Chinese investors participating in 271 deals, with total deal value of \$11.5 billion. **This represented almost 16% of the value of all technology deals in that year (\$72 billion).**¹⁴ China invested on the order of \$3-4 billion in early stage venture deals in 2015. The specific technology areas of these investments are covered in the next section.

These investments are consistent with China's goals made clear in President Xi Jinping's statements, successive Five Year Plans, Made in China 2025 and Project 863,¹⁵ namely, to:

- Establish China as one of the most innovative countries by 2020 and a leading innovator by 2030;¹⁶
- Become a leading global science and technology power by 2049 -- the 100th anniversary of the PRC;
- Double down on R&D of core information and communications (ICT) technologies...to develop technologies on its own, *acquiring expertise from abroad when indigenous development is not possible.*

The growing investments in U.S. technology overall, and early-stage ventures in particular, comprise a part of China's plan to acquire expertise from abroad and to develop indigenous innovation.

⁸ Lingling Wei, "China Issuing 'Strict Controls' on Overseas Investment," Wall Street Journal (November 26, 2016). Retrieved at <http://www.wsj.com>

⁹ While China's global FDI has been growing at 33% annually since 2003, a leading China think tank expects global FDI to decline in 2017 to a level closer to 2015 and well below \$200 billion. Lingling Wei, "China's Overseas Funding to Shrink," Wall Street Journal (January 14, 2017)

¹⁰ Thilo Hanemann and Daniel Rosen, "Chinese Investment in the United States; Recent Trends and the Policy Agenda" Rhodium Group Report (December 9, 2016). Retrieved at <http://www.rhg.com>

¹¹ These capital controls and the slower growth rate of the Chinese economy are likely primary causes for the forecasted China global FDI to decline in 2017.

¹² China Investment Monitor, Rhodium Group, January 17, 2017; Retrieved at <http://www.rhg.com>

¹³ "This strategy seems to be increasingly the norm in the tech industry, with Chinese companies making investments to soak up strategic technologies, capabilities, talent and brands that they can then take home." Ana Swanson, "Gold Rush: Chinese Tech Companies Invest Overseas," CKGSB Knowledge (April 20, 2015). Retrieved at <http://knowledge.ckgsb.edu.cn/2015/04/20/finance-and-investment/gold-rush-chinese-tech-companies-invest-overseas/>

¹⁴ Data retrieved from CB Insights, October, 2017; data includes all rounds: Seed/Angel, Series A-E+, Convertible Notes, and "Other VC" investments.

¹⁵ Project 863 is shorthand for the month (3/March) and year (1986) when it was introduced by China's leading strategic weapons pioneers to Deng Xiaoping. The proposal was approved and served as China's leading industrial R&D program, importantly reforming decision making to be less stove-piped and more collaborative; reorienting the procurement process; investing in training of technical experts; and developing technologies of strategic value.

¹⁶ "Xi Sets Targets for China's Science, Technology Progress" Xinhua (2016, May 30). Retrieved at <http://www.xinhuanet.com>

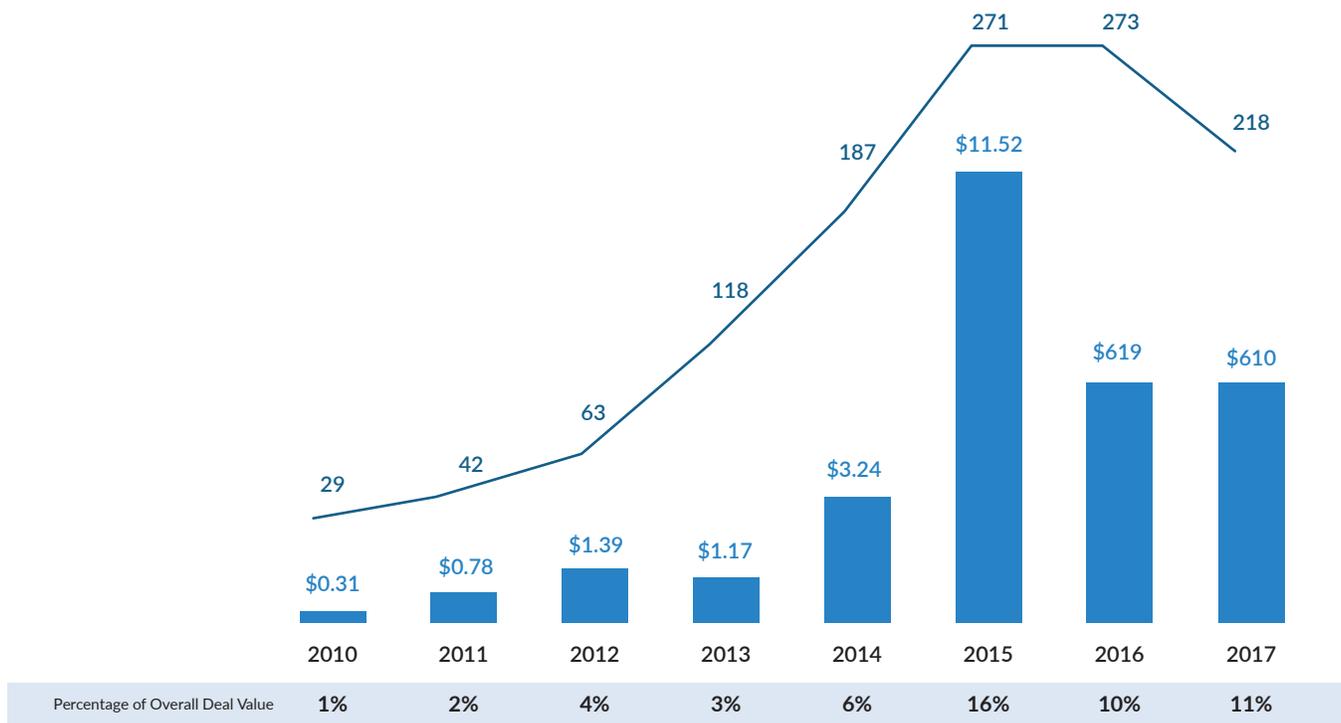


China's Investment in Critical Future Technologies

Investments from China-based¹⁷ investors into early-stage U.S. technology companies continue to grow in all sectors and are dispersed across all the stages of the investment lifecycle.¹⁸ Some notable investment data include:

- China-based investors participated in 1,201 financings in the U.S. from January, 2010 to October, 2017 contributing to roughly \$31 billion in venture-backed funding. Over the same period, overall funding into early stage technology was roughly \$372 billion, indicating that Chinese investors participated in 8% of overall deal value during this period (January, 2010 - October, 2017) hitting a peak of 16% in 2015 and remaining at roughly 10% in 2016 and 2017.
- Activity from Chinese investors peaked in 2015 participating in 271 deals valued at \$11.52 billion. In 2016, Chinese investors participated in 10% of deals valued at \$6.19 billion.¹⁹

Chart 1: Chinese Participation in U.S. Venture Capital Market, January 2010 - October 2017



■ Funding Participation (\$B) — Deals

Source CB Insights; Parameters: Seed/Angel; Series A-E; Convertible Note; Ovther VC Data through October 31, 2017



¹⁷ For the purposes of this inquiry, China-based investors include investors from mainland China and Hong Kong.

¹⁸ For the purposes of this study, we identified 537 unique investors from China that have invested in the United States from January 2010 to October 2017. These investors span from individual angel investors, Chinese entities serving as incubators or tech accelerators and traditional venture capital firms to corporations, banks, and hedge funds taking active stakes in early-stage companies. The full list of Chinese investment vehicle types included in the CB Insights database include: Incubator/Accelerator; Venture Capital; Corporation; Corporate Venture; Private Equity; Asset/Investment Management; Holding Company; Angel Investor; Investment Bank; Sovereign Wealth Fund; Angel Investor (Group); Hedge Fund; Advisory; Government; Diversified Financial Services; Merchant Bank; Family Office; Debt & Specialty Finance; Business Plan Competition

¹⁹ Data retrieved from CB Insights, October, 2017; Data includes all rounds: Seed/Angel, Series A-E+, Convertible Note, and "Other VC" investments.



Table 1: Dispersion of Chinese Investment in U.S. Venture Capital Market, 2010 - 2016

Showing deals from Jan 01, 2010 - Oct 31, 2017

	Seed/Angel	Series A	Series B	Series C	Series D	Series E+
% of deals	32.73%	26.31%	17.12	12.31%	5.70%	5.79%
Avg. deal size	32.73%	\$12.9M	\$34M	\$40.3M	\$61.1M	\$167.6M
Median deal size	\$1.4M	\$8M	\$17.5M	\$24M	\$36.5M	\$45M

- A majority of the investment occurred in the Seed/Angel stage (33% of all deals), followed by Series A (26% of all deals).²⁰ This corresponds with the recent increase in Chinese investment in early-stage technology deals and indicates that Chinese investors are interested in early looks at the most promising (even if yet unproven) technologies.
- By country, China invests far more in U.S. early stage technology companies than any other country outside the U.S. Details on this comparison by country are in Appendix 1.

Investment in Critical Technologies

China-based investors are particularly active in the emerging technology sectors of Artificial Intelligence, Augmented Reality/Virtual Reality, Robotics and Financial Technology. In 2015, Chinese investment in this portfolio of technologies represented approximately 20% of their overall investment, rising to 40% in 2016 and at 29% through the first three quarters of 2017.²¹

- **Artificial Intelligence (AI):** Between 2010-2017, Chinese investors participated in eighty-one AI financings, contributing to the roughly \$1.3 billion raised. Participation accelerated in 2014 and has continued through the end of the third quarter of 2017, with Chinese investors active in sixty-nine deals and \$1.2 billion in financing.
- **Robotics:** Chinese entities were active in nearly \$237 million of financing for Robotics startups between 2010-2017. Deal activity peaked in 2015 with Chinese participation in twelve deals and \$113 million in financing.
- **Augmented Reality/Virtual Reality (AR/VR):** Chinese investors participated in \$2.1 billion worth of deals during the period 2010-2017. In 2016, China-based investors participated in seventeen deals, contributing to the \$1.3 billion in total funding value.
- **Financial Technology (Fintech):** Investments in Fintech, including blockchain technology, continued their rapid pace in 2016 and 2017 with Chinese investors participating in forty-nine deals, valued approximately at \$1.4 billion. Overall, Chinese investors have participated in 100 deals, representing \$3.5 billion in funding for Fintech companies during 2010-2017.

²⁰ Seed/Angel stage is typically the first investment in an idea before the idea is proven and often attracts a different class of investors than those who might lead a later stage venture round (typically denoted by a letter such as "A", "B", etc.) leveraging a more proven idea or business model.

²¹ Charts of the Chinese investment activity in these four critical technologies are in Appendix 1 and select deals for 2016 are provided in Appendix 2 which illustrates China's technology focus in venture investing.



Two important trends stand out with the new wave of technology being funded. **First, the line demarcating products designed and used for commercial versus military purposes is blurring with these emerging technologies.** For example, VR for gaming is at a similar level of sophistication as the VR used in simulators for our armed forces.²² Facial recognition and image detection for social networking and online shopping has real application in tracking terrorists or other threats to national security; and much of today's commercial autonomous vehicle technology and drone technology solutions find their genesis in DARPA grants over the last two decades when the Department of Defense sought to develop autonomy for war-fighting purposes.

The current export control regime and the policy apparatus for vetting foreign investment in the U.S.—both of which are designed to keep sensitive technology, companies, and infrastructure out of the hands of our adversaries—are built on a framework of being able to clearly distinguish dual uses of a technology. This distinction becomes difficult when the technology itself is developed for commercial purposes and has widespread potential use as a fundamental technology building block such as artificial intelligence. With the blurring of the line between civilian and military use, faster development cycles and the increasing mobility of human capital globally, our current export control system becomes handicapped as a tool to manage how and where technology transfer occurs.

Second, these technologies – from artificial intelligence to robotics and virtual reality – will be foundational so that many applications or end-use technologies will be built upon them. These foundational technologies will be component technologies for future innovations much the same way that semiconductors have been components in all electronics, telecommunications and computing in the past several decades. This is especially true in the field of artificial intelligence, where the U.S. government is actively making investments to create the third wave of AI technology to achieve a future where machines can explain themselves to humans; where machines can create causal models, not just correlations; and where machines can take what they learn in one domain and apply the learnings to a completely different domain.²³ The breakthroughs that come with these new technologies will be the building blocks for innovations in the decades ahead. There is likely to be an interaction between the new capabilities that are available (through innovations in robotics, artificial intelligence and virtual reality) and new generations of uses, applications and products. The same phenomenon occurred when faster microprocessors, more storage or higher networking bandwidth became available and led to future innovations such as cloud computing, mobile phones and consumer applications for GPS. Consequently, it becomes even more critical that exports, foreign ownership, and technology partnerships with foreign entities do not become conduits for technology transfers that will directly enable key means of foreign military advantage. What is at risk for the U.S. is not only losing an edge in the foundational technology, but also in successive generations of applications and products that the foundational technology enables. According to Adam Segal, a specialist in emerging technologies and national security at the Council on Foreign Relations, “The Chinese leadership is increasingly thinking about how to ensure they are competitive in the next wave of technologies.”²⁴

²² Major Loren Bymer, “Virtual Reality Used to Train Soldiers in New Training Simulator,” U.S. Army News & Information (August 1, 2012). Retrieved at <https://www.army.mil/article/84453>

²³ Ed Felton and Terah Lyons, “The Administration’s Report on the Future of Artificial Intelligence,” White House Blog, October 12, 2016. Retrieved at: <https://www.whitehouse.gov/blog/2016/10/12/administrations-report-future-artificial-intelligence>

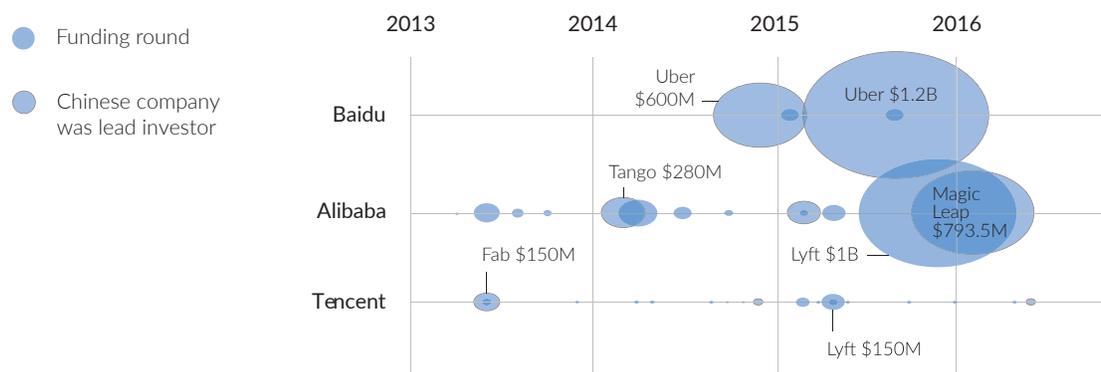


There are multiple ways Chinese invest in U.S. technology firms:

- 1. Investments in U.S. venture-backed startups through venture firms.** In the past 10 years, China's investments in U.S. technology firms were limited to joint ventures or acquisitions, but now there are an increasing number of green field investments²⁵ in venture-backed startups (both as limited partners of U.S. venture firms and through Chinese venture firms) as well as investments through Chinese private equity firms. Examples of Chinese venture firms include West Summit Capital, Westlake Ventures (owned by the Hangzhou government), GGV Capital, GSR Ventures, ZGC Capital, Hax and Sinovation. Sinovation (formerly known as China's Innovation Works) provides a great example of an active Chinese venture firm investing in the U.S.: founded in 2009, it manages three funds of \$1.2 billion in capital and has invested in almost 300 startups – including 25 in artificial intelligence. As evidence of its government sponsorship, Sinovation has received awards by China's Ministry of Science & Technology as well as the Municipal Science & Technology Committee of Beijing where the firm is headquartered. (An overview of Sinovation and Hax and their investments are profiled as case studies of Chinese venture capital firms in Appendix 3.) A sample listing of government-backed venture firms and their sources of capital are provided in Appendix 4.
- 2. Investments by Chinese companies.** Increasingly, Chinese internet companies such as Baidu, Tencent, Alibaba and JD.com are aggressively investing in venture-backed technology deals. In 2015, these companies participated in 34 deals worth \$3.4 billion, up from 7 deals in 2012 worth \$355 million.²⁶ Tencent is by far the most active (with 2x the deals in 2015 than the others combined) having started earlier with its investing but Baidu and Alibaba are not far behind. Some Chinese internet companies are championing investments in specific technologies; Baidu, for example has a clear investment focus in artificial intelligence. The chart that follows shows the growth of investment from 2013 to 2016 from these Chinese internet companies.²⁷

China is flooding Silicon Valley with cash

In recent years, Chinese companies have invested heavily in U.S. start-ups. Here are some high-profile deals involving Baidu, Alibaba and Tencent, often referred to as the Google, Amazon and Facebook of China



Source: Crunchbase

Darla Cameron/ The Washington Post

²⁴ John Markoff and Matthew Rosenberg, "China Gains on the U.S. in the Artificial Intelligence Arms Race," The New York Times (February 3, 2017). Retrieved at <http://www.nytimes.com>.

²⁵ Green field investments typically refer to new investments and sometimes a parent company's operations in a foreign country built from the ground up.

²⁶ "The Rise of China's Investment in U.S. Tech Startups," CBInsights Blog

²⁷ Elizabeth Dwoskin, "China Is Flooding Silicon Valley with Cash," Washington Post (August 6, 2016).



3. **Private equity (PE).** Chinese private equity is expanding at an unprecedented pace with the number of globally active funds at 672 (2013-2015), the highest in five years. Total value of Chinese PE deals in 2016 (through June) is at a record \$18 billion worldwide. In 2016, Chinese PE firms participated in the \$3.6 billion takeover of Lexmark, the \$2.75 billion purchase of Dutch chipmaker NXP Semiconductors and the \$600 million acquisition of Oslo-based Operat Software's web browser business.²⁸ Examples of Chinese private equity firms include AGIC, Legend Capital and Golden Brick Capital and these often partner with U.S. private equity firms, such as TPG (involved in acquiring a stake in China International Capital in 2012) and Carlyle (involved in purchase of Focus Media Holding in 2013). One of the most globally active China PE investors is Yunfeng Capital started by Alibaba Group founder Jack Ma.
4. **Special purpose vehicles.** There are also examples of special purpose investment vehicles like Canyon Bridge (Chinese capital and U.S. management expertise combined) which are solely formed to purchase a company and obscure the source of capital for a foreign acquisition, in this case, Lattice Semiconductor. Presumably, a special purpose vehicle is formed to enhance the possibility that the transaction will be approved by CFIUS.
5. **Acquisitions.** Chinese acquisitions continue to increase dramatically with the largest globally being China National Chemical Corporation's proposed takeover of Syngenta (Swiss pesticides) for \$43 billion. China's acquisitions of foreign companies are now equal to U.S. firms' acquisitions of foreign companies. In the U.S., the largest recent China-based acquisitions have been the electronics distributor, Ingram Micro (\$6.1 billion) and the U.S. hotel owner, Strategic Hotels & Resorts – owners of the Waldorf-Astoria Hotel (\$8.1 billion).

As long as U.S. policy supports open investment by all nations, we can expect increased investment from China through a broader number of vehicles, some cleverly designed to obfuscate Chinese capital and ownership. The investment activity *beyond acquisitions* is not tracked by the U.S. government and we have limited visibility into the investors, the technologies invested in, or the increase or decrease of investment flows, except through what is tracked by private data sources. However, even these private data sources are not comprehensively tracked by the U.S. government to assemble a holistic picture of what is happening.

²⁸ Cathy Chan, "Chinese Private Equity Funds Are Taking on the World's Giants", Bloomberg News (July 20, 2016)



China's Economic and Technology Goals

China has developed a leading global economy faster than any country in modern history. This transformation began with the reform and opening of China's economy under Deng Xiaoping in 1978. By 2015, China's GDP was \$11.4 trillion compared to the U.S. at \$18 trillion. However, in purchasing power parity (PPP), China is already slightly larger than the U.S. This represents the first time the U.S. has not been the largest economy since it overtook the U.K. in 1872.²⁹ Since the U.S. economy is growing at 1-3% and China's is growing at 5-7%, the trajectory is clear in narrowing the GDP gap (some projections show China's GDP exceeding U.S. GDP within the next decade)³⁰. The time scale during which this growth occurred is stunning as China's economy has grown from 10% of the U.S. economy in the 1970s to the second largest global economy in just fifty years. Analogous growth in the U.S. economy to global leadership took a century to achieve.

China plans to further transform its economy through a national focus on technology and indigenous innovation with a goal of import substitution. To accomplish this, China aims to displace the U.S. in key industries using its large market size to promote domestic champions which can become global leaders through state subsidies, access to low-cost capital and limiting China's domestic market access to foreign companies. China already leads the world in many key industries including overall manufacturing (accounting for almost 25% of global manufacturing in 2012), autos, high-tech products, where China produced 2.5 times the value of goods that the U.S. produced in 2012^{31,32}, and e-commerce³³. Beijing is home to the most Initial Public Offerings (IPOs) (2x the dollar value of the U.S.) and is the world's largest e-commerce retail market³⁴. In fact, China has the potential to lead in all internet-based industries aided by discriminatory domestic policies such as data localization requirements, forced technology transfers and the Great Firewall which enables control over the content and flow of data on the internet. Chinese domestic champions such as Baidu, Tencent and Alibaba enjoy privileged market access in China and are market leaders domestically, while also becoming leading global technology companies.

China's leaders recognize that to achieve its economic goals, the economy must transform even faster in the future than in its recent past. The Chinese government wants to "revitalize the nation through science, technology and innovation."³⁵ President Xi's strategy is for China to develop its own industries to be leading globally, develop more cyber talent, double down on R&D especially of core ICT technologies and transform China to be a powerhouse of innovation. One area China has targeted for global leadership is the design and production of semiconductors. "China's strategy relies, in particular, on large-scale spending, including \$150 billion in public and state-influenced private funds over a 10-year period aimed at subsidizing investment and acquisitions as well as purchasing technology."³⁶ Several official source documents clearly support these long-term economic and technology goals. (Summary descriptions of three documents are listed here with more documents and descriptions provided in Appendix 5.)

²⁹ Ben Carter, "Is China's Economy Really the Largest in the World?" BBC News (December 16, 2014)

³⁰ Malcolm Scott and Cedric Sam, "China and the U.S.: Tale of Two Giant Economies", Bloomberg News (May 12, 2016)

³¹ High tech products are defined by the World Bank as products with high R&D intensity such as aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery

³² Jeff Desjardins, "China vs. United States: A Tale of Two Economies," Visual Capitalist (October 15, 2015)

³³ By 2010, China already led the world in several commodity industries where the US previously led such as steel (with 8x our output), cotton, tobacco, beer, and coal.

³⁴ E-Marketer.com: "China Eclipses the U.S. to Become the World's Largest e-Commerce Market." Retrieved at <https://www.emarketer.com/Article/China-Eclipses-US-Become-Worlds-Largest-Retail-Market/1014364> (August 18, 2016)



- **Made in China 2025** is a plan designed to align State and private efforts to establish China as the world's pre-eminent manufacturing power by 2049 emphasizing the integration of information technology. Key prioritized sectors include advanced information technology, automated machine tools and robotics, aerospace and aeronautical equipment, maritime equipment and high tech shipping and biopharma and advanced medical products.³⁷
- **13th Five Year Plan of 2016-2020 "Internet Plus"**³⁸ which deepens reforms and priorities called for in *Made in China 2025* and emphasizes stronger control by the government over national networks as China continues to control the internet domestically and gains access to global networks by controlling key component and telecommunications technologies. Key aspects include³⁹:
 - Focus on catapulting China into a leading position in "advanced industries" including semiconductors, chip materials, robotics, aviation equipment and satellites;
 - Decreasing dependence on imports and innovation;
 - Increasing R&D spending to 2.5% of GDP (up from 2.1% from 2011-2015);
 - Creating a \$4.4 billion fund to invest in startups and new technologies
- **China's Mega Project Priorities** are 16 Manhattan-style projects⁴⁰ to focus on specific innovations. These are analogous to what is envisioned by Third Offset capabilities. In China these projects receive a national (not just a military) focus. Here are some selected examples (a complete list is in Appendix 6):
 - Core electronics, high-end general chips, basic software
 - Next generation broadband wireless mobile communications
 - Quantum communications
 - Classified defense-related projects (possibly satellite navigation and inertial confinement fusion)

Today, there are clear examples of Chinese indigenous innovation showing that China is doing more than copying technology – China is making progress on President Xi's goal to become one of the most innovative economies by 2020:

- **Micius Quantum Communications Satellite.** The 2016 launch of the Micius satellite suggests an aggressive push into quantum communications; expertise in quantum computing may someday enable the capability to break many existing encryption methods (based on factoring).
- **Sunway TaihuLight Supercomputer.** In June of 2016, China introduced the world's fastest supercomputer, the Sunway TaihuLight capable of theoretical peak performance of 124.5 petaflops. The TaihuLight is the first system in the world to exceed 100 petaflops (quadrillions of floating-point operations per second). More importantly, the previous version of this Chinese supercomputer used Intel microprocessors but the Sunway TaihuLight uses Chinese designed and manufactured microprocessors.⁴¹

³⁵ "Xi Sets Targets for China's Science, Technology Mastery" Xinhua (May 30, 2016).

³⁶ "Ensuring Long Term U.S. Leadership in Semiconductors," Executive Office of the President, President's Council of Advisors on Science & Technology, January, 2017. Retrieved at <http://www.whitehouse.gov/ostp/pcast>

³⁷ Scott Kennedy, "Critical Questions: Made in China 2025," Center for Strategic and International Studies" November 7, 2016. Retrieved at <http://www.csis.org/analysis/made-china-2025>.

³⁸ "China Unveils Internet Plus Action Plan to Fuel Growth," The State Council for the People's Republic of China. Xinhua (July 4, 2015) Retrieved at <http://www.english.gov.cn/policies>

³⁹ Lulu Chang, "China Outlines its Latest FYP Called Internet Plus," Digital Trends (March 6, 2016). Retrieved at <http://www.digitaltrends.com>.

⁴⁰ Michael Raska, "Scientific Innovation and China's Military Modernization," The Diplomat (September 3, 2013). Retrieved at <http://www.thediplomat.com>

⁴¹ Patrick Thibodeau, "China Builds World's Fastest Supercomputer without U.S. Chips," Computerworld (June 20, 2016), Retrieved at <http://www.computerworld.com>



- **Cruise Missile Incorporating Artificial Intelligence.** A cruise missile system with a high-level of artificial intelligence: a “semi-autonomous” weapon having the capability to avoid defenses and make final targeting decisions with a goal of destroying larger ships in a fleet like aircraft carriers.⁴²
- **Consumer Drones.** DJI's (Da-Jiang Innovation) market leadership in low-cost, easy-to-fly drones and aerial photography systems which have made this company the standard in consumer drone technology accounting for 70% of the worldwide drone market.
- **Autos.** In the auto industry, China plans to take advantage of two paradigm shifts to further its lead in the world's largest manufacturing industry: autonomous vehicles and electric vehicles. China is investing in an electric vehicle supply chain including battery technology and aims to have 50% of the world's electric vehicle production and 90% of global battery production capacity.⁴³

According to Tangent Link, a U.K.-based provider of defense reports, “one of the enduring myths in many Western CEO-suites is that the Chinese are great at copying and stealing, but will have difficulty ‘out-inventing’ the West. This arrogant and outdated hypothesis is crumbling fast.”⁴⁴

By some measures of innovation, China is already leading and without question China's capacity to innovate is rising:

- In patent applications, China already surpasses the U.S. with over 1 million patent applications received by the China State Intellectual Property Office in 2015 (up 19% year over year) compared to 589,410 patent applications received by the U.S. Patent and Trademark Office (up 2% year over year).⁴⁵
- In academic research papers, Chinese authorship of articles in peer-reviewed international science journals increased such that China is now in 2nd place (2011) up from 13th place just a few years earlier.⁴⁶
- China spent 1.6% of GDP in R&D in 2011 but has a stated goal of spending 2.5% of GDP R&D by 2020 – about \$350 billion.⁴⁷ Combined U.S. business and federal government R&D spending is 3-4% of GDP.
- China awarded 1,288,999 Science, Technology, Engineering & Mathematics (STEM) degrees in 2014 – more than double the degrees the U.S. awarded at 525,374 degrees.⁴⁸

To assess the comparative innovation capability between China and the U.S., McKinsey recently analyzed the industries where China has an innovation lead.⁴⁹ In traditional manufacturing industries where low costs provide a competitive advantage, China leads in innovation by leveraging a concentrated supply base and expertise in automation and modular design (examples: electronics, solar panels, construction equipment). In consumer markets, China leads given its market size (examples: smartphones, household appliances). In engineering markets, China has

42 John Markoff and Matthew Rosenberg, “China Gains on the U.S. in the Artificial Intelligence Arms Race,” *The New York Times* (February 3, 2017); and Lei Zhao, “Nation's next generation of missiles to be highly flexible,” *China Daily* (August 19, 2016)

43 John Longhurst, “Car Wars: Beijing's Winning Plan” November, 2016.

44 “Quantum Leap: Who Said China Couldn't Invent?” *Geo-political Standpoint (GPS) Report 85* (October 14, 2016), Tangent Link

45 “China vs. U.S. Patent Trends: How Do the Giants Stack Up?,” *Technology & Patent Research*. Retrieved at <http://www.tprinternational.com>

46 Hannas, William C.; Mulvenon, James and Puglisi, Anna B. *China Industrial Espionage*. New York: Routledge, 2013. Chapter 3

47 Hannas, *China Industrial Espionage*, Chapter 3 and “The U.S. Leads the World in R&D Spending”, *The Capital Group Companies* (May 9, 2016). Retrieved at <http://www.thecapitalideas.com>

48 Jackie Kraemer and Jennifer Crow, “Statistic of the Month: Engineering and Science Degree Attainment by Country”, *National Center on Education and the Economy* (May 27, 2016). Retrieved at <http://www.ncee.org>

49 Erik Roth, Jeongmin Seong, Jonathan Woetzel, “Gauging the Strength of Chinese Innovation,” *McKinsey Quarterly* (October, 2015).



mixed results leading in high-speed rail but not in aerospace, nuclear power or medical equipment. In science-based industries such as branded pharmaceuticals or satellites, China is behind the U.S. but China is investing billions of dollars to catch up. (The McKinsey analysis is provided in Appendix 7.)

Many of the critical future technologies attracting venture focus today such as artificial intelligence, augmented reality and autonomous vehicles are likely to have large consumer-based markets implying that China will apply its advantages both in efficiency-driven and customer-focused industries to these new technologies with the potential to lead in innovation and be global market share leaders. The success of DJI in the consumer drone market with 70% worldwide share is consistent with this McKinsey analysis. In artificial intelligence, the race between the U.S. and China is so close that whether the Chinese “will quickly catch the U.S...is a matter of intense discussion and disagreement in the U.S. Andrew Ng, chief scientist at Baidu, said the U.S. may be too myopic and self-confident to understand the speed of the Chinese competition.”⁵⁰ And in the field of advanced industrial robotics, China is leveraging its market and investment capital to ultimately lead in the design and manufacture of robots.⁵¹ Given there are many industries where China already leads the world in innovation and given China’s massive scale and national focus on science and technology advancement, it would be foolhardy to bet against China’s continued progress even in the areas where they do not lead today. A further concern is that China’s long-term, national focus on innovation and expertise in advanced manufacturing might make China a more attractive destination market for new technologies--especially hardware technologies--since there is both less funding appetite in the U.S. for non-software technologies and less of an ecosystem for developing and manufacturing these technologies.

Implications for the Department of Defense (DoD)

U.S. military superiority since World War II has relied on both U.S. economic scale and technological superiority. The size of the U.S. economy allows DoD to spend \$600 billion per year (while remaining only 3% of GDP in 2016) which equals the defense spending of the next eight largest nations combined. In 2016, China was the second largest spender at \$215 billion, up 47% from the previous year while the U.S. spending remained flat.⁵² U.S. technological preeminence enabled the series of offset strategies which included the First and Second Offsets and now DoD is currently working to maintain technology superiority in its Third Offset strategy.

China’s goal to be the preeminent global economy combined with its emphasis on technology transfer and innovation constitutes a major strategic competition with the U.S. There are several areas of concern:

1. China’s transformation to be the manufacturer for the world means more supply chains are owned by China, which creates risks to U.S. military technology and operations. For example, the Aviation Industry Corporation of China (AVIC) is a Chinese-state owned aerospace and defense company which has now procured key

⁵⁰ John Markoff and Matthew Rosenberg, “China Gains on the U.S. in the Artificial Intelligence Arms Race.” The New York Times (February 3, 2017).

⁵¹ Farhad Manjoo, “Make Robots Great Again,” The New York Times (January 26, 2017).

⁵² 2016 Fact Sheet, Stockholm International Peace Research Institute (SIPRI) and “The Military Balance”, International Institute for Strategic Studies (IISS) 2016. Retrieved at <http://www.en.m.wikipedia.org>



components of the U.S. military aircraft supply chain.⁵³ Additionally, as the U.S.-based semiconductor industry focuses on high-end designs and moves older, low-end designs offshore, the Chinese semiconductor industry now controls a significant percentage of the supply of older chips used in maintaining U.S. military aircraft and equipment designed 40 years ago and still in service.

2. China has targeted several key technologies such as jet engine design which will reduce current U.S. military superiority and is actively working to acquire companies that will close this gap.
3. China's industrial espionage and cyber theft efforts continue without adequate U.S. investment in manpower and programs to thwart these efforts. This allows technology transfer at an alarming rate.⁵⁴
4. China's investment strategy (through venture and private equity investments as well as acquisitions) includes the fundamental technologies which will likely be the sources of innovation for the next several decades: artificial intelligence, autonomous vehicles, robotics, augmented and virtual reality, gene editing, etc. As a result, China has access to U.S.-based innovation in the same areas and at the same time which could negate advantages for the U.S. Further, when the Chinese make an investment in an early stage company developing advanced technology, there is an opportunity cost to the U.S. since that company is potentially off-limits for purposes of working with DoD.
5. Beyond the threat from investments alone, China's national focus on mega projects (analogous to the U.S. space program in the 1960s to not only develop technology but create demand for technology) complements the increase in military spending as China gains experience in manufacturing and refining new technologies for practical use.
6. DoD does not currently have agreed-upon emerging technologies the U.S. must protect although there has been extensive work on export controls to protect technology products from being shipped to U.S. adversaries.

DoD began developing a list of critical technologies in 2016 in an effort known as the Joint Acquisition Protection & Exploitation Cell (JAPEC). The mission of JAPEC is to "integrate protection efforts across the Department to proactively mitigate losses and exploit opportunities to deter and disrupt adversaries which threaten U.S. military advantage." JAPEC is working to identify critical acquisition programs and technologies that require protection as well as assess vulnerabilities associated with known losses and implement advanced protection mechanisms.⁵⁵ However, there is much work left to do to consolidate the technologies across DoD requiring protection and determine which of those are the most critical. The JAPEC effort complements the government's robust system of export controls which are designed to comply with trade agreements, embargoes, sanctions and other political measures to meet U.S. national security and foreign policy objectives.

Finally, there is no technology landscape map to help DoD understand the fundamental component technologies required to protect applications or end-use technologies embedded in acquisition programs. For example, semiconductor technology is a fundamental component technology today that would be required to protect capabilities inherent in almost all acquisition programs. This is likely to be the case in the future with such fundamental technologies as artificial intelligence, robotics, autonomous vehicles, advanced materials science, etc. With agreed-upon emerging technologies to protect and a technology landscape to clarify the value-added map of technologies (from components to end-use applications), the U.S. government can be much clearer about what acquisitions to deny through a reformed CFIUS process and resource allocation to thwart industrial espionage or cyber theft.

⁵³ "How America's Giants Are Aiding China's Rise", Geo-political Standpoint (GPS) Report 84, October 13, 2016, Tangent Link.

⁵⁴ The IP Commission Report (2013)

⁵⁵ Brian D. Hughes, "Protecting U.S. Military's Technical Advantage" presented at the 18th Annual NDIA Systems Engineering Conference in Springfield, VA, October 28, 2015. Retrieved at <http://www.acq.osd.mil>

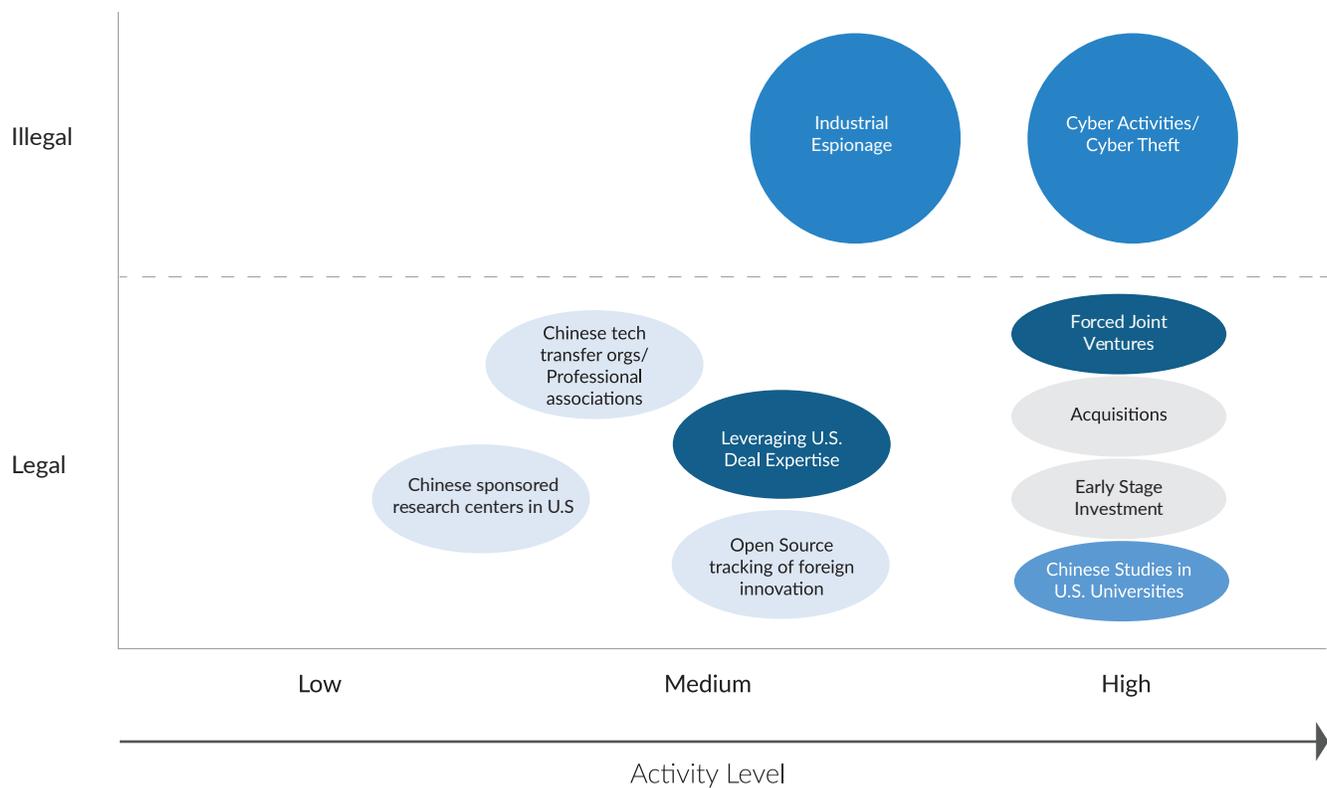


China's Multiple Vehicles for Technology Transfer

Given the authoritarian nature of China's government, China can focus resources from a variety of different sources to enable a broad transfer of scientific knowledge and technology. Additionally, China coordinates these different sources to achieve a larger impact through a well-articulated industrial policy documented in its Five-Year and other plans. The principal vehicles discussed so far are investments in early-stage technologies as well as acquisitions. When viewed individually, some of these practices may seem commonplace and not unlike those employed by other countries. However, when viewed in combination, and with the resources China is applying, the **composite picture illustrates the intent, design and dedication of a regime focused on technology transfer at a massive scale.**

The following table compares these transfer vehicles on a relative scale of the level of activity for China in the U.S. compared to other countries. This illustrates that what differentiates China from other countries' activities in the U.S. is the scale of China's efforts. Naturally, the most troublesome of all the vehicles are the illegal ones – the outright theft of technology and intellectual property which is very cost-effective for China.

Vehicles for Chinese Technology Transfer from the U.S.



China's Activity in the U.S. Relative to Other Countries' Activities in the U.S.



The 8 principal sources and methods for technology transfer *in addition to investments and acquisitions* are:

1. Industrial espionage

For years, the Chinese have been engaged in a sophisticated industrial espionage program targeting key technologies and intellectual property to enhance commercial enterprises and support domestic champions.⁵⁶ This has recently been on the rise as Randall Coleman, Assistant Director of the FBI's Counterintelligence Division, observed in 2015 that espionage caseloads are up 53% in the past two years and that in an FBI survey of 165 companies, 95% of those companies cite China as the perpetrator. "China's intelligence services are as aggressive now as they've ever been" underscoring the pervasive nature of intellectual property and trade secret theft.⁵⁷ The FBI reports that China pays Chinese nationals to seek employment in targeted U.S. technology firms (where there is sensitive technology that China identifies it needs) where they become "insiders" and more readily exfiltrate valuable intellectual property. Fortunately, convictions of Chinese nationals and naturalized citizens for industrial espionage are also on the rise, up 10x since 1985⁵⁸.

Despite the rise in convictions, there is no way to know how big this problem really is. The scale of the espionage (through some of the methods described below) continues to increase and it would be difficult to quantify this problem without more resources applied by both the FBI and the Defense Department's various counterintelligence agencies.

2. Cyber theft

China's cyber capabilities are among the strongest in the world probably only exceeded by Russia and the U.S. although some have argued that China's cyber successes to date demonstrate more about U.S. system vulnerability than Chinese capabilities. Regardless, cyber theft is an ideal tool for China given the asymmetric vulnerability of the U.S. (given how much information is digitally accessible) and the plausible deniability given the difficulty of attribution in cyber-attacks. Several documented high profile cyber theft incidents are described in Appendix 8 and may be the tip of the iceberg in terms of the numbers of incidents and their scale. As former NSA Director General Keith Alexander famously told Congress in 2012, this represents the "greatest transfer of wealth in history". At that time, it was estimated that U.S. companies lose \$250 billion per year through intellectual property theft and another \$114 billion due to cybercrime, totaling \$338 billion of impact each year. "That's our future disappearing in front of us," warned General Alexander.⁵⁹

As reported in the IP Commission Report of 2013, Verizon worked with 18 private institutions and government agencies to estimate that:

- 96% of the world's cyber espionage originated in China;
- \$100 billion in lost sales and 2.1 million in lost jobs result from this theft;
- \$300 billion worth of intellectual property is stolen each year.⁶⁰

⁵⁶ 2016 Report to Congress of the US-China Economic & Security Review Commission (November, 2016) and Hannas, China Industrial Espionage, Chapter 8

⁵⁷ Shanie Harris, "FBI Probes 'Hundreds' of China Spy Cases", The Daily Beast (July 23, 2015). Retrieved at <http://www.thedailybeast.com>

⁵⁸ Notes from briefing, "Economic and S&T Intelligence Collection" by Joseph P. O'Neill, Faculty Member, National Intelligence University, November 28, 2016.

⁵⁹ Josh Rogin, "NSA Chief: Cybercrime Constitutes the 'Greatest Transfer of Wealth in History' " Foreign Policy Magazine (July, 2012). Retrieved at <http://www.foreignpolicy.com>

⁶⁰ The IP Commission Report (2013)



What really distinguishes China from other nation-state actors in cyber attacks is the sheer scale of activity as China dedicates a massive amount of manpower to its global cyber activities. The FBI's former deputy director for counterintelligence reported in 2010 that the China deploys between 250,000 and 300,000 soldiers in the People's Liberation Army (3PLA) dedicated to cyber espionage. Within another part of the armed forces, 2PLA has between 30,000 and 50,000 human spies working on insider operations.⁶¹ China's cyber activity is not solely focused on a national security agenda. In fact, much of this activity can be deployed to support China's economic goals in stealing valuable intellectual property to support China's technology transfer. Additionally, China recently passed two laws--the anti-terrorism law and the cybersecurity law--which are of concern since they could be used to gather sensitive commercial information from U.S. companies legally.⁶²

3. Academia

For many years, China has sent an increasing number of students to the U.S. In 2016, there were 328,000 Chinese foreign nationals studying at U.S. colleges and universities (1/3 of all foreign students). Chinese foreign nationals represent 1/2 of all foreign applicants.⁶³ The U.S. educational system has come to rely on the financial contribution of these foreign students especially at the undergraduate level.

Statistics on U.S. STEM programs highlight the large proportion of foreign students:

- 84% of foreign students in PhD programs were studying in science and engineering (2001-2011);⁶⁴
- For doctoral programs, 57% of engineering, 53% of computer science and 50% of math and statistics candidates were foreign; half of these were Chinese;⁶⁵
- 54% of patents issued by universities include foreign student's work;⁶⁶
- 45% of STEM undergraduates are foreign and 1/3 of these are from China.⁶⁷

From this data, we can infer that 25% of the graduate students in STEM fields are Chinese foreign nationals. Since these graduates do not have visas to remain in the U.S., nearly all will take their knowledge and skills back to China. Academia is an opportune environment for learning about science and technology since the cultural values of U.S. educational institutions reflect an open and free exchange of ideas. As a result, Chinese science and engineering students frequently master technologies that later become critical to key military systems, amounting over time to unintentional violations of U.S. export control laws. The phenomena of graduate student

⁶¹ Joshua Philipp, "Rash of China Spy Cases Shows a Silent National Emergency", The Epoch Times (April 25, 2016). Retrieved at <http://www.theepochtimes.com>

⁶² **Anti-terrorism law** passed in December, 2015 which gives the Chinese government broad access to technical information and decryption codes when state security agents demand it for investigating or preventing terrorism. Telecommunication and internet service providers "shall provide technical interfaces, decryption and other technical support and assistance" when required. Chris Buckley, "China Passes Antiterrorism Law that Critics Fear May Overreach," The New York Times (January 6, 2016). Retrieved at <http://www.nytimes.com>.

Cybersecurity law passed in November, 2016 contains vague language aimed at preventing network intrusions that would require U.S. companies submit their technology, possibly including source code, to security reviews with Chinese officials. There are an expansive list of sectors defined as part of China's critical information infrastructure such as telecommunications, energy, transportation, information services and finance all of which would be subject to security reviews. The law does not specify what a security review will entail. Several U.S. companies are concerned about the increased costs of doing business in China as well as the need to provide company sensitive information to the Cybersecurity Administration of China to prove that their equipment, software and operations are safe. Josh Chin and Eva Dou, "China's New Cybersecurity Law Rattles Foreign Tech Firms," Wall Street Journal (November 7, 2016). Retrieved at <http://www.wsj.com>.

⁶³ Project Atlas, Institute of International Education, Fall 2015. Retrieved at <http://www.iese.org>.

⁶⁴ "Survey of Graduate Students and Postdoctorates in Science & Engineering", National Science Foundation, November, 2015.

⁶⁵ Drew Desilver, "Growth from Asia Drives Surge in US Foreign Students," Pew Research Center (June 18, 2015)

⁶⁶ National Science Foundation Survey, November, 2015

⁶⁷ Donisha Adams and Rachel Bernstein, Science (November 21, 2014); Retrieved at <http://www.sciencemag.org>



research increasingly having national security implications will inevitably increase as the distinction between military and civilian technology blurs. Further, since there are close ties between academia and U.S. government-sponsored research – including at our national laboratories – ensuring that foreign nationals are not working on sensitive research paid for by the U.S. government (including DoD) will become increasingly important.

Chinese companies are also approaching U.S. academic institutions to promote joint research and attract future talent. As an example, Huawei has partnered with UC-Berkeley to focus jointly on artificial intelligence research. Huawei made an initial commitment of \$1 million in funding to cover areas such as deep learning, reinforcement learning, machine learning, natural language processing and computer vision⁶⁸ More recently, Huawei has approached MIT with an offer for a grant to build a joint research facility.

4. China's use of open sources tracking foreign innovation

China has made collecting and distributing science and technology information a national priority for decades. “By 1985, there were 412 major science & technology intelligence institutes nationwide [in China]...employing ...60,000 workers...investigating, collecting, analyzing, synthesizing, repackaging, benchmarking and reverse engineering.”⁶⁹ In 1991, the book, *Sources and Methods of Obtaining National Defense Science & Technology Intelligence*, detailed a comprehensive account of China's foreign military open-source collection (known as “China's Spy Guide”) collecting all types of media (including verbal information prized for its timeliness over written information) and making them available in database form. The National Internet-based Science & Technology Information Service Systems (NISS) makes 26 million holdings of foreign journals, patents and reports available to the public around the clock. Chinese exploitation of foreign open-source science and technology information is a systematic and scale operation making maximum use of diversified sources: scanning technical literature, analyzing patents, reverse engineering product samples and capturing conversations at scientific meetings. This circumvents the cost and risk of indigenous research.⁷⁰

5. Chinese-based technology transfer organizations

At the national level, China has more than a dozen organizations that seek to access foreign technologies and the scientists who develop them (not counting the clandestine services, open-sources, and procurement offices). These organizations are led by the State Administration of Foreign Experts Affairs (SAFEA). SAFEA's success is evident in the 440,000 foreign experts working in China annually. Complementing SAFEA is the State Council's Overseas Chinese Affairs Office (OCAO) which provides overseas Chinese (whether they have lived in China or not) with the opportunity to support their ancestral country. The Ministry of Human Resources and Social Security⁷¹ is involved heavily in foreign recruitment and foreign technology transfer including the Overseas Scholars and Experts Service Center to interact with Chinese students studying abroad. The Ministry of Science & Technology (MOST) also dedicates significant resources to acquiring foreign technology including 135 declared personnel in overseas embassies and consulates.

⁶⁸ Li Yuan, “Chinese Technology Companies, including Baidu, Invest Heavily in AI Efforts”, Bloomberg News (August 24, 2016)

⁶⁹ Hannas, *China Industrial Espionage*, Chapter 2, p. 22.

⁷⁰ Hannas, *China Industrial Espionage*, Chapter 2

⁷¹ Formerly known as the Ministry of Personnel.



The Overseas Scholars and Experts Service Center sponsors associations at many universities which serve as an organized means to transfer technology to China. Many of the national programs also have complementary provincial and municipal organizations specifically focused on the skills and talent that can benefit a local area. These organizations make available debriefing rooms, free translators, personnel to make travel arrangements, dedicated “transfer centers” and face-to-face meetings between technology experts and Chinese company representatives.

China also promotes “people to people” exchanges through a network of NGOs (e.g., the China Science and Technology Exchange Center and the China Association for the International Exchange of Personnel) that insulate overseas specialists from the potential risks of sharing technology directly with PRC government officials.⁷²

6. Chinese research centers in the U.S. to access talent and knowledge

There are now increasing examples of Chinese firms setting up research centers to access U.S. talent and technology:

- In 2013, Baidu set up the Institute for Deep Learning in Silicon Valley to compete with Google, Apple, Facebook and others for talent in the artificial intelligence field.⁷³ Baidu recently hired former Microsoft executive Qi Lu as its group president and chief operating officer. Lu was the architect of Microsoft’s strategy for artificial intelligence and bots.
- Another example is the Zhong Guan Cun (ZGC) Innovation Center opened in May, 2016 in Silicon Valley.
- A new type of research center is TechCode: an entrepreneurs’ network “committed to breaking down geographic barriers and eliminating potential inequalities of international cooperation” according to its website. As a network of entrepreneurs, Tech Code is a system of incubators (“startups without borders”) worldwide (Beijing, Shanghai, Shenzhen, Gu’an, Silicon Valley, Seoul, Tel Aviv and Berlin) that leverages an online development platform for projects focused on China’s development and funded by the Chinese government.⁷⁴
- In addition, there are several research centers promoting a sustainable environment and clean energy including the U.S.-China Clean Energy Research Center (CERC) recently expanded and promoted together by President Obama and President Xi.

7. U.S.-based associations sponsored by the Chinese government

There are many professional associations which bring Chinese engineers together such as the Silicon Valley Chinese Engineers (6000 members), the Hua Yuan Science & Technology Association (HYSTA) and the Chinese Association for Science and Technology (CAST). The largest concentration of China’s science and technology advocacy groups in the U.S. are in California and Silicon Valley in particular. “ ‘The Valley’ is ground [zero] for... legal, illegal and quasi-legal practices that fall just below the thresholds set by U.S. law.”⁷⁵ With these professional associations being one of the primary targets, the Chinese have implemented a variety of programs such as the “Thousand Talents Program” to bring this technology home by recruiting Chinese engineers with offers of career

⁷² Hannas, China Industrial Espionage, Chapter 4

⁷³ Li Yuan, “China Races to Tap Artificial Intelligence”, Wall Street Journal (August 24, 2016)

⁷⁴ “Startups Nation” from the Tech Code website, <http://www.techcode.com>

⁷⁵ Hannas, China Industrial Espionage, Chapter 5, p. 122



advancement, increased compensation, the opportunity do basic research or to lead their own development labs in China. China set a goal of bringing back 500,000 Chinese overseas students and scholars from abroad by 2015.⁷⁶ Another example is “Spring Light” which pays overseas Chinese scientists and engineers to return home for short periods of lucrative service that may include teaching, academic exchanges, or working in government-sponsored labs. In addition, “Spring Light” includes a global database of Chinese scholars to match specific technology needs to pools of overseas talent.⁷⁷

The Chinese diplomatic missions to the U.S. directly support technology transfer as embassy or consulate officials facilitate a wide variety of venues and forums supported by U.S. investors and local governments to promote Chinese investment. Seven examples of these are (descriptions of these forums are in Appendix 9):

- Silicon Valley Innovation and Entrepreneurship Forum (SVIEF)
- DEMO China
- Silicon Valley-China Future Forum
- China Silicon Valley
- The Global Chamber San Francisco (GCSF)
- U.S.-China VC Summit & Startup Expo
- Chinese American Semiconductor Professionals Association (CASPA)

The messaging for these associations and programs is often controlled by the “United Front” which is a propaganda arm for the Chinese government to promote a positive image of China and Chinese culture around the world.⁷⁸

8. Leveraging technical expertise of U.S. private equity, venture firms, investment banks and law firms

As China has invested more in the U.S., its investment entities have enhanced their deal expertise by working with U.S. investment banks or law firms who benefit from increased business. As China works with U.S. private equity and venture firms to invest in deals, these firms benefit through the increased value of equity stakes in these investments. Many U.S. law firms have built a practice in advising Chinese companies on how to structure deals to increase the likelihood of CFIUS approval for transactions. Consulting organizations have also built a practice in structuring mitigation agreements that will be more likely to gain CFIUS approval. As China's investments have ramped up dramatically in the past three years, the level of deal expertise has increased considerably.

⁷⁶ Xu Liyan and Qiu Jing, “Beyond Factory Floor: China's Plan to Nurture Talent,” Yale Global Online (September 10, 2012). Retrieved at <http://yaleglobal.yale.edu/content/beyond-factory-floor-chinas-plan-nurture-talent>

⁷⁷ Hannas, China Industrial Espionage, Chapter 5.

⁷⁸ The Confucius Institutes, launched in 2004, are a good example which offer Chinese language and cultural instruction often in partnership with local universities. However, their purpose is also to portray Chinese history and policy in the best possible light so that China can be seen as a “pacifistic, happy nation. In the past decade, these institutes have been welcomed on some 350 college campuses across the world including Stanford, Columbia and Penn.” as quoted in Pillsbury's The Hundred-Year Marathon. Given a history of trying to influence the curriculum of Chinese history and Chinese studies at colleges, there are now a number of colleges which are disbanding these institutes.



How are these multiple vehicles used together for coordinated impact?

Because the Chinese Communist Party is much more involved in planning economic activity and supporting companies (not only through state-owned-enterprises but also in favoring national champions it supports globally like Huawei), there is a great deal more coordination of investment along with other vehicles of technology transfer to accomplish the larger economic goals specified in China's documented plans. The scale of the Chinese economy is so large that not everything is coordinated centrally; however, the importance and degree of political control by the Communist Party ensures that investments support national goals and are not purely guided by commercial interest. The goals of many of the government-funded Chinese venture capital firms are focused on experience with advanced technologies and recruiting talent – not simply making money.

There are not enough examples to definitively say there is a standard playbook of all the vehicles used in combination. However, there are a few examples where several of these technology transfer vehicles are used together. Documented examples show targeted cyber-attacks to understand the scope of technology and intellectual property of value and where that resides within a company followed by cyber theft or industrial espionage to steal that technology.⁷⁹ In another example, Chinese cyber attackers manipulated company sales figures to weaken that company's view of itself and make it more likely to accept a purchase offer from a Chinese company. In a variation on this theme, a Chinese customer placed large orders with a public company and then cancelled them to weaken a company's results as a market surprise. Finally, there is the example of Silicon Valley startup, Quixey, who relied on a large investor, Alibaba, as one of its most important customers promising access to the Chinese market. However, Alibaba refused to pay Quixey for a custom contract to provide specialized technology to search within apps in Alibaba's operating system. Alibaba subsequently took advantage of Quixey's cash squeeze to negotiate favorable financing terms which put Alibaba in a better position to later make an offer for the technology or the company.⁸⁰ Thus, through a combination of technology transfer vehicles, China can achieve more than with a single vehicle.

Before the U.S.-China Economic and Security Review Commission, a former forensic auditor and counterintelligence analyst testified that China is executing a series of campaigns targeting specific industries he studied including telecommunications and network equipment (to benefit global champions Huawei and ZTE), information security, semiconductors, media and entertainment and financial technology. He outlined a process that involves many of the vehicles described here as key technologies are targeted, studied, stolen and applied within Chinese companies. He characterized these as cyber-economic campaigns which “are persistent, intense, patiently executed and include the simultaneous execution of such a large and diverse set of legal and illegal methods, individuals and organizations, there's little chance the targeted U.S. competitors can effectively defend or compete in the future without significant support of the U.S. government.”⁸¹

⁷⁹ "APT1: Exposing One of China's Cyber Espionage Units", Mandiant Report, 2013. Retrieved at <http://www.fireeye.com/content/dam/fireeye-www.services/pdfs>

⁸⁰ Elizabeth Dwoskin, "China Is Flooding Silicon Valley with Cash," Washington Post (August 6, 2016).

⁸¹ Jeffrey Z. Johnson, President & CEO of SquirrelWerkz, in testimony before the US-China Economic and Security Review Commission, January 26, 2017.



U.S. Government Tools to Thwart Technology Transfer

1. **The Committee on Foreign Investment in the U.S. (CFIUS) is one of the only tools in place today to govern foreign investments that could be used to transfer sensitive technology to adversaries, but it was not designed for this purpose and is only partially effective.**⁸² CFIUS was established by statute in the Foreign Investment and National Security Act of 2007 (FINSA) which formally gave an interagency working group the power to review national security implications of foreign investments in U.S. companies or operations. The Treasury Department is the lead agency among 14 participating agencies. The nine voting member agencies are Treasury, State, Commerce, the United States Trade Representative, Office of Science & Technology Policy, Defense, Homeland Security, Justice and Energy. While transaction reporting is voluntary, CFIUS can and does monitor transactions beyond those that are voluntarily submitted and can initiate a review of any of these. CFIUS is required to provide clearance for reviewed transactions on a short timeline: within 75 days unless a Presidential review is required and, in that case, there are 90 days for a review and a Presidential recommendation.

As those involved in the CFIUS process readily acknowledge, CFIUS is a blunt tool not designed for the purpose of slowing technology transfer. CFIUS only reviews some of the relevant transactions because transactions that do not result in a foreign controlling interest are beyond its jurisdiction. There are many transaction types such as joint ventures, minority investments and purchased assets from bankruptcies that are effective for transferring technology but do not result in foreign control of a U.S. entity and are, therefore, outside of CFIUS' jurisdiction. In 2017, Senators Cornyn (R-TX) and Feinstein (D-CA) introduced the Foreign Investment Risk Review Modernization Act (FIRRMA) which expands CFIUS' jurisdiction to cover the key transaction types beyond acquisition which might result in technology transfer. This legislation has broad support within the Administration including public statements by the White House, Secretaries of Defense, Treasury, Commerce and the Attorney General.

The workload for CFIUS is increasing rapidly. CFIUS reviews about 150 transactions per year but this is rising. At the same time, the number of transactions which have national security implications is also rising as Chinese purchases of U.S.-based companies or assets now represent the largest number of CFIUS reviews. Congress has not provided dedicated funding for CFIUS reviews so this critical process must be handled within existing agency budgets. The proposed FIRRMA legislation recognizes the need for increased resources to handle a growing CFIUS caseload. A review of strengths and weaknesses of the current CFIUS process are included as Appendix 10.

⁸² CFIUS was established by executive order in 1975 during the OPEC oil embargo of the 1970s to prevent oil-rich nations with greatly expanding wealth from gaining too much control of U.S. assets.



2. **Export controls** are designed to prevent sensitive technologies or products from being shipped to adversaries.⁸³ In practice, there are several problems that may result from using export controls to thwart technology transfer to an adversary. First, export controls are often backward-looking in terms of specifying the technologies that are critical since most controls focus on products rather than broad technologies. Second, there is diffused responsibility for export controls since some are controlled by the State Department and some by the Commerce Department with DoD in an advisory role.⁸⁴ Third, with the technologies that are the focus of venture investing (far in advance of any specific products produced or military weapons), export controls have not been traditionally effective. Failure in effectiveness has largely been a function of not having the foresight to place these technologies on an export control list nor the political will to do so. In other words, the authority is in place for effective export controls if there is agreement among DoD, State and Commerce about what technologies to protect. However, since complying with export controls is a company's responsibility, there is a question of whether early-stage technology companies understand the controls or have resources within a trade compliance function to handle this complexity.

While the restricted export lists (EAR and CCL76) can accommodate the regulation of software-based technologies such as artificial intelligence, controlling a broad technology will be highly controversial within the venture and technology community where the largest markets are for benign, commercial purposes. In fact, there is great pressure to specify technologies as narrowly as possible when writing export controls to facilitate more U.S. exports especially if the technologies are available outside the U.S. As the venture investment data indicates, the regulations do not prevent (or even deter) foreign investment in seed or early-stage companies. Additionally, it is not the purview of the export control enforcement authorities to proactively seek out companies developing new technologies or to investigate the relationship between investors and employees of a startup. Lastly, export controls will be much more effective if there is an international effort to protect the technology; otherwise, there may be an unintended consequence of the technology developing faster outside the U.S. aided by foreign investment through an allied country. If and when a dual-use technology is deemed worthy of control, the U.S. government can impose unilateral controls while it undertakes an effort to have the technology controlled internationally through the multilateral export control regimes but this process can take up to three years and may not be successful.

3. **VISAs** for Chinese foreign national students studying in the U.S. are controlled by the State Department and not scrutinized for fields of study with the protection of critical technologies in mind.

⁸³ The current U.S. export control system is based on the requirements of the Export Administration Act, the International Economic Powers Enhancement Act (IEEPA), the Arms Export Control Act (AECA) and the resulting implementing regulations (most notably, Export Administration Regulations (EAR) and International Traffic in Arms Regulations (ITAR)). The EAR and ITAR each have a control list: the Commerce Control List (CCL) and the U.S. Munitions List (USML). Several other Federal Agencies have niche export control regulations such as the Department of Energy, the Food and Drug Administration and the National Nuclear Security Administration, among others. The CCL lists certain dual-use, fully commercial, and less sensitive military items while items that are considered defense articles and services are included in the USML. USML is a list of articles and/or services that are specifically designed, developed, configured, adapted or modified for a military application and do not have a predominant civil application or civil performance equivalent; have significant military or intelligence applicability; and are determined or may be determined as a defense article or defense service. Taking a closer look at the dual-use paradigm, the CCL enumerates dual-use, commercial, and less sensitive military goods, software, and technology in categories ranging from materials processing, electronics, sensors and lasers, to navigation and avionics. Each item has an Export Control Classification Number ("ECCN") that specifies characteristics and capabilities of the items controlled in each ECCN. The definition of an export is intentionally broad and includes the provision of technical information to a foreign national anywhere in the world.

⁸⁴ Previous attempts at consolidating the organizational responsibility for export controls to a single government department focused on controlling a single list have not been implemented.



Policy Framework

Given the multi-faceted nature of this problem which cuts across not only many parts of the executive branch of government but also private sector businesses and academia, there are multiple dimensions of a policy framework:

1. **Defensive policies: how to deter the technology transfer occurring.** The primary defensive levers are:
 - a. CFIUS reforms
 - b. Export controls
 - c. Immigration policy for foreign students
 - d. Level of counterintelligence resources
2. **Proactive policies: how to stimulate technology development and innovation in the economy.** Levers are:
 - a. Level of basic research investment
 - b. Incentives for encouraging U.S. students to study STEM fields
 - c. Pro-growth and productivity enhancing economic policies
3. **Whole of Government scope:** actions or policies that require a coordinated strategy and multiple agencies/ departments working together. If there is agreement on what technologies to protect then multiple parts of the executive branch can enforce the defensive policies levers (CFIUS reforms, export controls, immigration policy, counterintelligence resources) to protect those technologies

The most comprehensive way to address the scale and long-term nature of Chinese technology transfer would be:

- both defensive and proactive policies as well as
- a “whole of government” approach coordinating a new China policy and the tools of the U.S. government.

Only with a “whole of government” approach would the U.S. government be able to effectively enlist the support of the private sector and academia.

There are three principal decisions to make regarding the *defensive* policies:

1. Breadth of technologies to protect
2. International cooperation to seek: how closely the U.S. government should act with allies formally to stem further technology transfer
3. Immigration policy for highly-educated foreign students in STEM fields



The principal decision to make regarding the proactive policies is the *level of investment* in basic research, talent and the processes to commercialize innovation. Federal funding of R&D in the U.S. is at 0.7% of GDP or far from its peak during the 1960s of 2% of GDP falling behind China, Japan, Korea, Finland, Sweden, Denmark and Germany as a percent of GDP. The U.S. economy today continues to benefit from the innovations arising from federal research which created entirely new industries at the forefront of technology today including those based on semiconductors, GPS, the internet, hydraulic fracturing, genomics, and many others. To benefit from a thriving future economy, we must increase the investment we are making today in federally-funded research and the talent to drive a growing pipeline of innovations and technology breakthroughs. Additionally, to preserve our technological advantage we must take steps to ensure "a healthy and secure national security innovation base that includes both traditional and non-traditional defense partners"⁸⁵ including early-stage companies.

⁸⁵ Summary of the National Defense Strategy, January 2018, "Sharpening the American Military's Competitive Edge", p. 11



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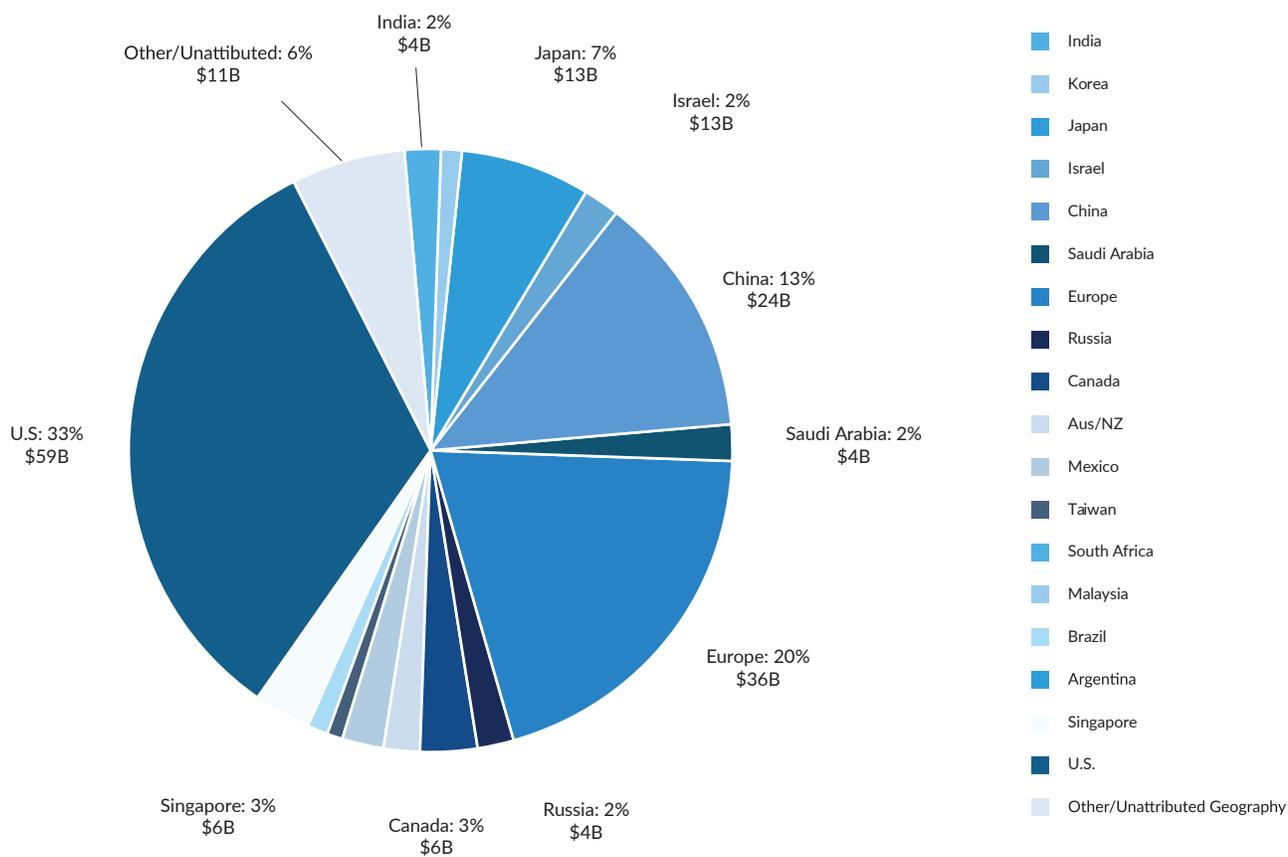
- Appendix 1:** China Investment in Critical Technologies
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APPENDIX 1: Chinese Investment in Critical Technologies

Compared to other sources of investment, Chinese entities ranked only behind domestic U.S. sources (\$59 billion) and Europe (\$36 billion), but well ahead of Japan (\$13 billion), Russia (\$4 billion), Israel (\$4 billion), India (\$4 billion), and Korea (\$1 billion).

Chart 2: Worldwide Investment in U.S. Venture-backed Companies 2015 - 2017

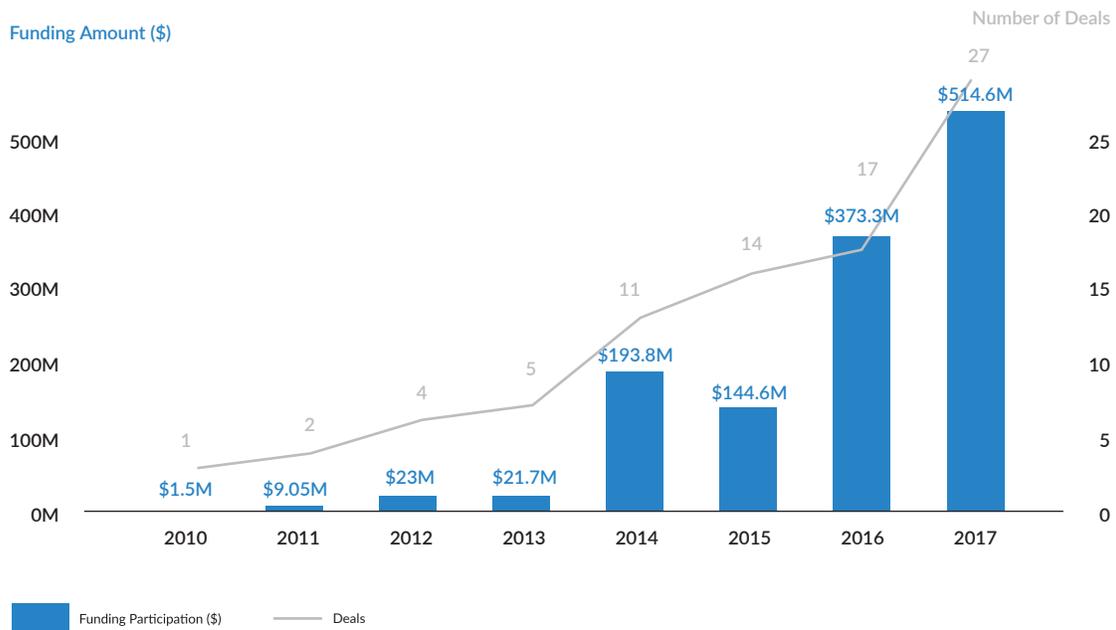


Source: CB Insights; Search parameters include: Seed/Angel; Series A-E+; Convertible Note; Other VC

Source: CB Insights; Search parameters include: Seed/Angel; Series A-E+; Convertible Note; Other VC

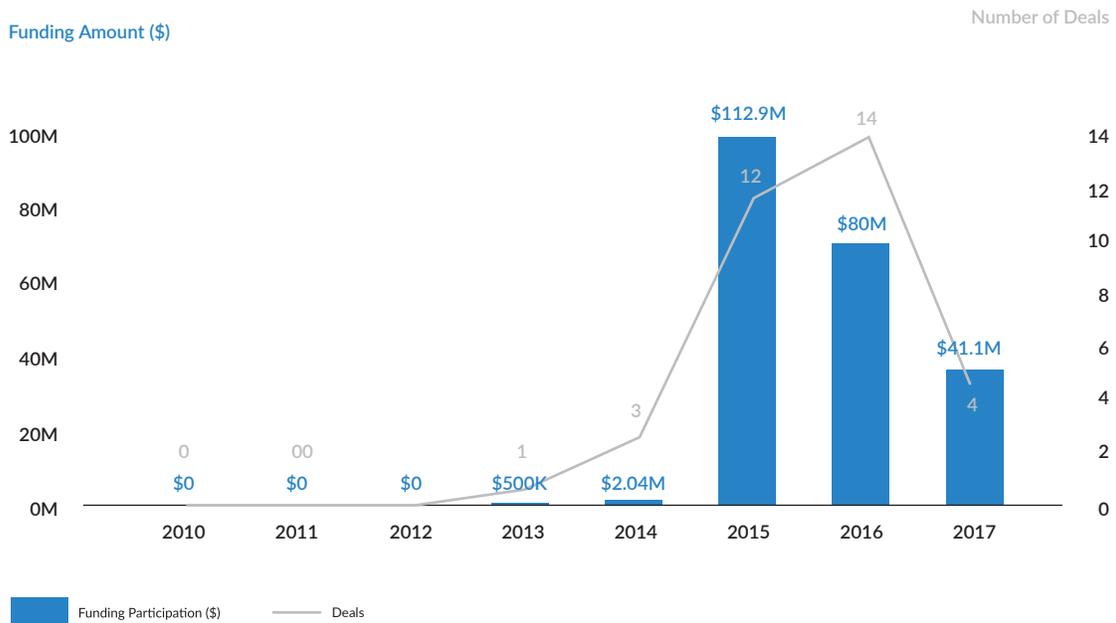


Chart 3: Chinese Investment in U.S. Artificial Intelligence Companies, 2010 - 2017
\$1.3 Billion in Deal Value; 81 deals



*CB Insights Search parameters include: Seed/Angel; Series A-E+; Convertible Note; Other VC

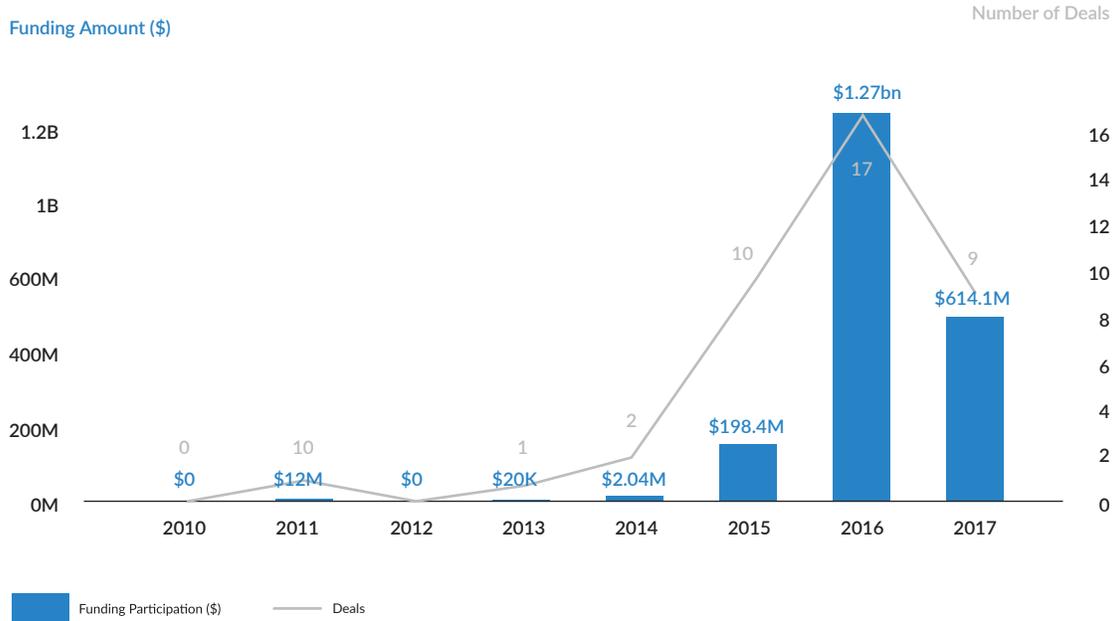
Chart 4: Chinese Investment in U.S. Robotics Companies, 2010 - 2017
\$237 Million in Deal Value; 34 Deals



*CB Insights Search parameters include: Seed/Angel; Series A-E+; Convertible Note; Other VC

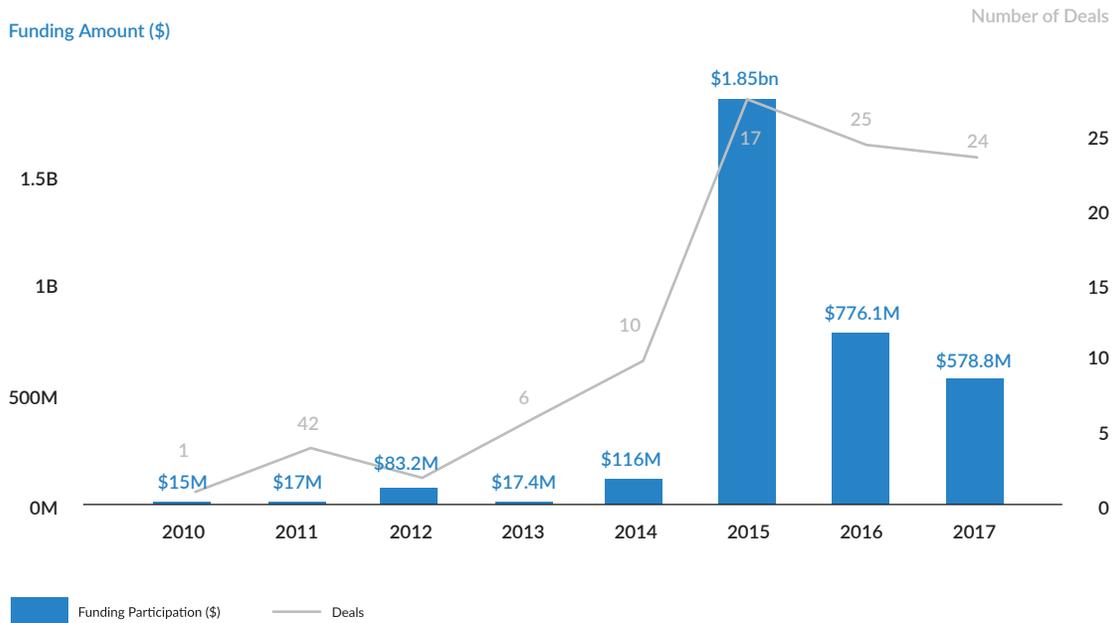


Chart 5: Chinese Investment in U.S. AR/VR Companies, 2010 - 2017
\$2.1 Billion in Deal Value; 40 deals



*CB Insights Search parameters include: Seed/Angel; Series A-E+; Convertible Note; Other VC

Chart 6: Chinese Investment in U.S. FinTech Companies, 2010 - 2017
\$3.5 Billion in Deal Value; 100 Deals



*CB Insights Search parameters include: Seed/Angel; Series A-E+; Convertible Note; Other VC



APPENDIX 2: Select Chinese Venture Deals in 2016 Illustrating Technology Focus⁸⁶

Company	Focus Area	Round Amount (\$M)	China Investors	Date	Location
Magic Leap	Augmented Reality	\$798.5	Alibaba Group, Enjoyor Group	Feb-16	Florida
Zoox	Autonomous Vehicles	\$200	AID Partners	May-16	California
Unity Technologies	Game Development Platform	\$181	China Investment Corporation, Frees Fund	Aug-16	California
Velodyne	LiDAR Sensor Technology	\$150	Baidu	Aug-16	California
NextVR	VR Content	\$80	CITIC Guoan, NetEase, Capital, China Assets Holdings, CMC Holdings	Jul-16	California
Razer	Gaming Hardware and Products	\$75	Hangzhou Liaison Interactive	Jun-16	Massachusetts
Circle Internet Financial	Consumer Payments	\$60	Baidu	Jun-16	Massachusetts
Meta	Augmented Reality	\$50	Tencent, Lenovo Group, Ningbo GQY, Horizons Ventures, Banyan Capital	Jun-16	California

⁸⁶ CBInsights data



Appendix 3: Case Studies of Chinese Venture Firms: SINOVIATION and HAX

Sinovation Ventures

Sinovation Ventures is a venture capital firm domiciled in China with an office in Silicon Valley. The firm was founded by Dr. Kai-Fu Lee in September 2009 and invests in early stage companies (Series A and Series B) in the United States and China. The company focuses on the following investment areas: Internet of Things connected devices, developer tools; and online education. Sinovation's portfolio includes companies developing artificial intelligence, robotics, financial technology and AR/VR technologies.⁸⁷

Some sample portfolio companies include⁸⁸:

- **Swivl:** Swivl, owned and operated by Satarii, is the maker of a personal cameraman robotic video device. Swivl turns an iOS device into a personal cameraman with wireless microphone.
- **Robby:** Robby manufactures self-driving delivery robots that can autonomously navigate sidewalks to the consumer's door. This can reduce the costs for the on-demand meal, grocery, and package delivery industry by eliminating the high costs of human deliverers, which can ultimately lead to lower costs for the consumer.
- **Deep Vision:** Deep Vision is a deep learning company that is developing computer vision for cars, robots, drones and machines of all type. Deep Learning-powered breakthroughs are ushering in a revolution in computer vision which combine big data sets and powerful data centers.
- **SPACES:** SPACES is an independent virtual-and mixed-reality company based in Los Angeles, CA. SPACES is working with such companies as Microsoft, NBCUniversal, Big Blue Bubble and The Hettema Group, among others, to develop and produce a wide range of projects across all VR and MxR platforms and technologies, including Oculus Rift, HTC Vive, Microsoft HoloLens, Samsung Gear VR, PlayStation VR and Google Cardboard.

Sinovation Ventures has invested in almost 300 start-ups so far, including many well-known internet companies such as Zhihu, Dianxin, Umeng, Tongbu Network, Wandoujia, Anquanbao, Kuaiya, Qingting FM, Yaochufa, Weiche, Moji Weather, Elex, Kakao, Baozou Comics, Face++, VIPKID, Boxfish, U17, SNH48, ImbaTV, Molbase, Ebest, Maihaoche, EALL, The ONE Piano, Zaijia, Joy Run, Horizon Robotics, Niu, Planetary Resources, etc. and Meitu which is expected to go public on the Hong Kong Stock Exchange soon.⁸⁹

⁸⁷ <http://www.sinovationventures.com/>

⁸⁸ Data retrieved from CB Insights Database

⁸⁹ <https://www.crunchbase.com/organization/sinovation-ventures#/entity>

⁹⁰ Ibid.



The firm combines incubation and investment offerings to facilitate the growth of companies that suit the Chinese marketplace. It has been awarded as a cutting-edge “National-Level Technology Company Incubator” by China’s Ministry of Science and Technology (MOST). It has also been recognized as an “Incubation Base for Strategic Emerging Industries in Beijing” and a “Zhongguancun National-Level Innovative Model of Incubator for Indigenous Entrepreneurship” by Municipal Science and Technology Committee of Beijing, where the Firm’s headquarters is based. Sinovation Ventures has established itself as a top-tier venture capital firm in China and has been backed by leading investors around the world. It currently manages three U.S. dollar funds and two RMB funds, with a total asset under management of \$1.2 billion (or about RMB 8 billion).⁹⁰

Hax

HAX is a hardware accelerator that has helped over 30 companies launch in the past 2 years. Based in Shenzhen and with an office in San Francisco, HAX provides end-to-end technical and financial support to early-stage hardware companies through its “Interactive Manufacturing Process”, which enables rapid development of manufacturable products.

Between 2014 and 2016, Hax participated in nearly half of all deals involving Chinese investors (14 of 29 deals). HAX companies receive up to \$25,000 to \$100,000 each and access to the SOS Ventures Hardware scaling fund.⁹¹

Some examples of Hax investments include:

- **Petronics:** Petronics is the creator of “Mousr”, a robotic mouse that has sensors, actuators, and intelligence that actually sees a cat and responds to its hunting movements like a real animal would.
- **Dispatch:** Dispatch is creating a platform for local delivery powered by a fleet of autonomous vehicles designed for sidewalks and pedestrian spaces.
- **Clean Robotics:** Clean Robotics provides trash sorting robots for offices.

HAX is backed by SOS Ventures, a venture firm with headquarters in Shenzhen and an office in San Francisco. It funds a handful of accelerators similar to Hax – Indie Bio in the biosynthetic space; Chinaccelerator for pure software; and Food-X for food-related startups. SOS Ventures provides funding at the seed, venture, and growth stage, providing expertise and technical assistance to entrepreneurs in areas such as engineering, mass manufacturing, product/market fit, messaging, and presentation. The company’s website claims funding for over 500 startups.⁹²

⁹¹ Retrieved at <https://www.crunchbase.com/organization/haxlr8r#/entity>

⁹² Retrieved at <https://www.sosv.com/>



Appendix 4: Chinese Government-Backed Funds in Silicon Valley⁹³

Company	Tie to Local Government	Total Money Raised	Select Investments
Westlake Ventures	Owned by Hangzhou government	\$66 million (\$16 million already available and \$50 million pending approval for transfer out of the country)	WI Harper Group, SVC Angel Fund, Amino Capital, FreeS Fund, Spider Capital, Benhamou Global Ventures
ZGC Capital Corporation	Indirectly owned by 17 state-owned enterprises, including China State Construction and Beijing Industrial Development Investment Management Company.	\$60 million so far, plans to raise \$500 million by 2020	KiloAngel, Danhua Capital, Plug & Play (in the process), Santa Clara office building
HEDA Investment Co.Ltd	HEDA is a fund set up by Hangzhou Economic and Development, an economic development zone under municipal government of Hangzhou	\$500 million	None yet: Focusing on information technology and bio tech.
Shanghai Lingang Economic Development Group	Supervised by the state-owned Assets Supervision and Administration Commission of the State Council (SASAC) of Shanghai.	None yet; plans to raise an overseas fund this year	A San Francisco office building for \$42 million.
Research Institute of Tsinghua University in Shenzhen	Half-owned by the municipal government of Shenzhen, and the other half is owned by Tsinghua University.	Tens of millions of dollars	TEEC (Tsinghua Entrepreneurs & Executives Club) Angel Fund, Early-stage startups

Appendix 5: China's Economic and Technology Goals

Made in China 2025 is a plan aligning State and private efforts to establish China as the world's pre-eminent manufacturing power by 2049. "Its guiding principles are to have manufacturing be innovation-driven, emphasize quality over quantity, achieve green development, optimize the structure of Chinese industry and nurture human talent."⁹⁴ *Made in China 2025* highlights 10 priority sectors emphasizing the criticality of integrating information technology with industry.

⁹⁴ Scott Kennedy, "Critical Questions Made in China 2025," Center for Strategic and International Studies; Retrieved at <https://www.csis.org/analysis/made-china-2025>



Key sectors prioritized include:

- Advanced information technology
- Automated machine tools and robotics
- Aerospace and aeronautical equipment
- Maritime equipment and high tech shipping
- Biopharma and advanced medical products
- New energy vehicles & equipment

12th Five Year Plan of 2011-2015 lists a “new generation information technology industry” as one of the seven strategic and emerging industries to develop. Policies and practices were put in place to (1) prioritize indigenous innovation, especially in high-performance integrated circuit products, (2) promote domestic champions and (3) encourage technology acquisitions

- CT priorities include
 - Mobile communications,
 - Next generation internet
 - Internet of things
 - Cloud computing
 - Integrated circuits
 - New display technologies
 - High-end software & servers
- Policies and practices:
 - Prioritize indigenous innovation, especially in high-performance integrated circuit products
 - Promote domestic champions: pursue M&A, reorganizations and alliances between upstream and downstream enterprises
 - Encourage technology acquisitions, participation in standards setting & moving up the value chain

13th Five Year Plan of 2016-2020 “Internet Plus”⁹⁵ deepens reforms and priorities called for in *Made in China 2025* and emphasizes stronger control by the government over network-related issues as China continues to control the internet within China and gains access to global networks by controlling key component and telecommunications technologies

- Plan goal to “Encourage hundreds of thousands of people’s passion for innovation, building the new engine for economic development”
- Leverages large internet base of 649 million users, 557 million of whom access the internet with a mobile phone
- Deliver to large cities 100 MBps internet bandwidth and provide broadband access to 98% of the population living in incorporated villages

⁹⁵ Lulu Chang, “China Outlines its Latest FYP Called Internet Plus.”



- ICT priorities include:
 - Expansion of network economic space
 - New generation information infrastructure,
 - Advancements in Big Data
 - Enhanced information security and cyberspace governance
 - Fostering of domestic capabilities in:
 - Artificial intelligence
 - Smart hardware
 - New displays and intelligent mobile terminals,
 - 5th generation mobile communications
 - Advanced sensors and wearable devices

Medium and Long-Term Plan for Science & Technology Development is the most far-reaching of government plans to “shift China’s current growth model to a more sustainable one, to make innovation the driver of future economic growth and emphasize the building of an indigenous innovation capability.”⁹⁶ There are 3 strategic objectives:

- Building innovation-based economy through indigenous innovation
- Fostering an enterprise-centered technology system and enhancing Chinese firms’ innovation
- Achieving major breakthroughs in targeted strategic areas of development and basic research and boosting domestically owned intellectual property

Project 863: China’s National High Technology Program is designed to overcome the shortcomings in national security through the use of science & technology

- Encompasses development of dual-use technology (civilian and military applications)
- Lays a foundation for indigenous innovation

China’s Mega Project Priorities are 16 Manhattan-style projects⁹⁷ to bring together the focus on specific innovations and the resources to ensure progress. These are outlined in Appendix 6.

⁹⁶ Hannas, Chinese Industrial Espionage, Chapter 3

⁹⁷ Michael Raska, “Scientific Innovation and China’s Military Modernization”, The Diplomat (September 3, 2013), Retrieved at <http://www.thediplomat.com>



Appendix 6: Chinese National Science and Technology Major Special Projects Mega-Projects as of October, 2016

Original Announced National Science and Technology Major Special Projects Contained in the '2006-2020 Medium and Long-Term S&T Development Plan'	Agencies in Charge
Core Electronics, high-end general chips, basic software	Ministry of Industry and Information Technology (MIIT)
Ultra large scale integration manufacturing technology	Beijing, Shanghai governments
High-end computer numerical controlled machine tools and basic manufacturing technology	National Development and Reform Commission, MIIT
Water pollution control and treatment	Ministry of Environmental Protection
Large-scale oil and gas fields and coal-bed methane development	China Petroleum, China United Coal-bed Methane Co.
Next generation broadband wireless mobile communications	Ministry of Science & Technology (MOST), National Energy Bureau, Tsinghua University
Genetic transformation and breeding of new plants	MIIT, Datang Electronics, CAS, Shanghai Institute of Microsystems, China Putian
Major new drug development	Ministry of Agriculture
High-resolution Earth observation system	MOST, Ministry of Health, People's Liberation Army (PLA) General Logistics Department
Prevention and control of major infectious diseases	State Administration for Science, Technology and Industry for National Defense (SASTIND), China National Space Administration
Large passenger aircraft	MOST, Ministry of Health, PLA General Logistics Department
Manned spaceflight and lunar exploration project	MIIT, Commercial Aircraft Corp. of China
3 Unidentified Classified Defense-Related Mega-Projects (candidates include Beidou Satellite Navigation System and Inertial Confinement fusion)	
New Additional National Science and Technology Major Special Projects Contained in the 'Science, Technology and Innovation 2030 Plan'	
Aero-engines and gas turbines	SASTIND, China Aircraft Engine Corp.
Quantum communications	
Information networks and cyber security	
Smart manufacturing and robotics	
Deep-space and deep-sea exploration	
Key materials	
Neuroscience	
Health care	

Source: Dr. Tai Ming Cheung, Associate Professor and Director of the Institute on Global Conflict and Cooperation (IIGC) at University of California, San Diego



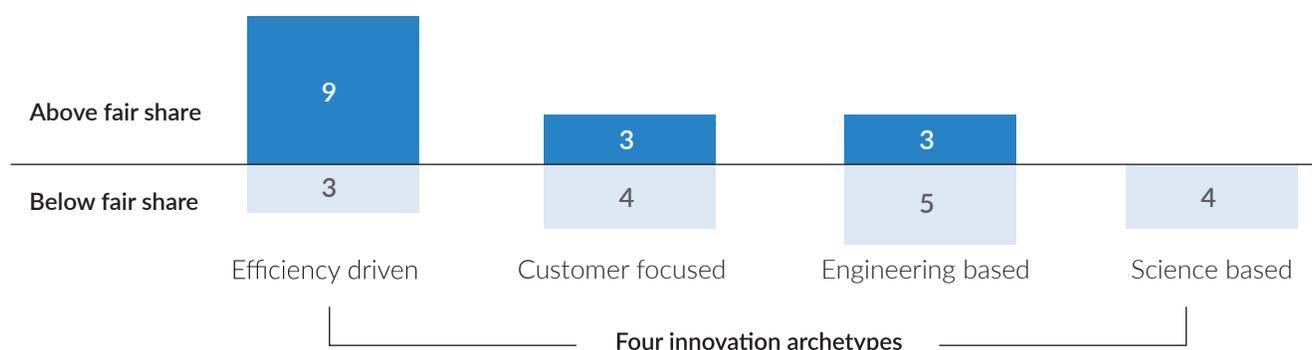
Appendix 7: McKinsey Study -- Industries Where China Leads in Innovation

To assess the comparative innovation capability between China and the U.S., McKinsey recently analyzed in what industries China was developing an innovation lead and in what industries China is lagging.⁹⁸

- In traditional manufacturing-based industries where low costs provide a competitive advantage, it is not surprising that China is leading the world. These industries would include electronics, solar panels and construction equipment where a combination of a large and concentrated supply base, agile manufacturing, modular design and flexible automation all provide benefits.
- In its consumer markets (which are customer-focused), China has a natural advantage given the sheer size of the market of 1.3 billion people (4x that of the U.S.) and this advantage is compounded when markets are protected. Industries where China again leads the world would include household appliances, smartphones (functionality delivered at low cost) and internet software companies (Alibaba, Baidu and Tencent).
- In engineering-based industries, the results are mixed. The best example is high-speed rail where innovation has been matched with local demand and government sponsorship. China accounts for 86% of the global growth in railroads since 2008. Other examples would be wind power and telecommunications equipment (Huawei and ZTE). China is not yet leading in automobile engines, aerospace, nuclear power or medical equipment.
- In science-based industries, such as branded pharmaceuticals, the results are poor. Here, the massive growth and national focus on R&D spending have not yet paid dividends. These investments naturally take a long time to pay off and the Chinese government is actively working to remove obstacles to enable Chinese firms to lead. This is an area where focus on national mega projects can be fruitful since they concentrate government sponsorship with focused resources and local demand. For example, China is rapidly improving its drug discovery and medical trials process to favor its domestic companies. Gene editing is a technology where the government sees tremendous promise and is actively supporting.

The following chart summarizes this industry-grouping analysis:

Chinese Industries: actual vs expected performance performance in innovation
(based on China's share of global GDP¹), number of industries = 31



¹China's share was 12% in 2013.

Source: IHS Global Insight; International Data Corporation; annual reports; McKinsey Global Institute analysis

⁹⁸ Erik Roth, Jeongmin Seong, Jonathan Woetzel, "Gauging the Strength of Chinese Innovation," McKinsey Quarterly (October, 2015).



Appendix 8: Largest Chinese Cyber Attacks

- **Breach of more than two dozen major weapons system designs** in February, 2012 from the military and defense contractors including those for the advanced Patriot missile system (PAC-3), an Army system for shooting down ballistic missiles (Terminal High Altitude Area Defense, THAAD) and the Navy's Aegis ballistic-missile defense system, the F-35 Joint Strike Fighter, the F/A-18 fighter jet, the V-22 Osprey, the Black Hawk helicopter and the Navy's new Littoral Combat Ship⁹⁹
- **"Titan Rain"** a series of coordinated attacks for multiple years since at least 2003 which compromised hundreds of government computers stealing sensitive information¹⁰⁰ " In 2004, an analyst named Shawn Carpenter at Sandia National Laboratories traced the origins of a massive cyber espionage ring back to a team of government sponsored researchers in Guangdong Province in China. The hackers, code named by the FBI "Titan Rain," stole massive amounts of information from military labs, NASA, the World Bank, and others."¹⁰¹
- **PLA Unit 61398** (a cyberforce within the Chinese military) which penetrated the networks of >141 blue chip companies across 20 strategically targeted industries identified in China's 12th Five Year Plan for 2011-2015 such as aerospace, satellite and telecommunications and IT. Among other areas of theft, source code was stolen from some of the most prominent U.S. technology companies such as Google, Adobe and others; Google announced this in January, 2010. This resulted in the U.S. indictment of 5 members of this organization. According to Mandiant, PLA Unit 61398 is just one of more than 20 cyber attack groups within China.¹⁰²
- **"Hidden Lynx"** which according to Symantec has a long history of attacking the defense industrial sector of Western countries with some of the most sophisticated techniques has successfully attacked the tech sector, financial services, defense contractors and government agencies since at least 2009¹⁰³
- "DHS says that between December 2011 and June 2012, cyber criminals targeted **23 gas pipeline companies** and stole information that could be used **for sabotage purposes**. Forensic data suggests the probes originated in China."¹⁰⁴
- "Canadian researchers say in March, 2105 that Chinese hackers attacked U.S. hosting site **GitHub**. GitHub said the attack involved "a wide combination of attack vectors" and used new techniques to involve unsuspecting web users in the flood of traffic to the site. According to the researchers, the attack targeted pages for two GitHub users—Great Fire and the *New York Times*' Chinese mirror site—both of which circumvent China's firewall."¹⁰⁵

⁹⁹ Ellen Nakashima, "Confidential Report Lists U.S. Weapons System Designs Compromised by Chinese Cyberspies", Washington Post (May 27, 2013). Retrieved at <http://www.washingtonpost.com>

¹⁰⁰ Nathan Thornburgh, "Inside the Chinese Hack Attack", Time (August 25, 2005). Retrieved at <http://www.content.time.com>

¹⁰¹ Josh Rogin, "The Top 10 Chinese Cyber Attacks (that We Know of)," Foreign Policy (January 22, 2010) Retrieved at <http://www.http://foreignpolicy.com/2010/01/22/the-top-10-chinese-cyber-attacks-that-we-know-of/>

¹⁰² "APT1: Exposing One of China's Cyber Espionage Units", Mandiant Report, 2013.

¹⁰³ "Hidden Lynx--Professional Hackers for Hire", Symantec Official Blog (September 17, 2013). Retrieved at <http://www.symantec.com>

¹⁰⁴ Robert Knake, "Five Chinese Cyber Attacks that Might Be Even Worse than the OPM Hack," Defense One (June 15, 2015). Retrieved at <http://www.defenseone.com>.

¹⁰⁵ Knake, "Five Chinese Cyber Attacks that Might Be Even Worse than the OPM Hack"



- **“The Commerce Department’s Bureau of Industry and Security** had to throw away all of its computers in October 2006, paralyzing the bureau for more than a month due to targeted attacks originating from China. BIS is where export licenses for technology items to countries like China are issued.”¹⁰⁶
- **Breach of the U.S. Office of Personnel Management (OPM)** in 2014 where the personnel files of 4.2 million former and current government employee as well as the security clearance background information for 21.5 million individuals was stolen. Former NSA Director Michael Hayden said that this would compromise our national security for an entire generation.¹⁰⁷

¹⁰⁶ Rogin, “The Top 10 Chinese Cyber Attacks (that We Know of)”

¹⁰⁷ “The OPM Breach: How the Government Jeopardized our National Security for More than a Generation,” Committee on Oversight & Government Reform, U.S. House of Representatives, 114th Congress (September 7, 2016).



Appendix 9: U.S. Events with Chinese Sponsorship

1. **Silicon Valley Innovation and Entrepreneurship Forum (SVIEF)**, according to its website “is an international conference designed to foster innovation and promote business partnerships connecting U.S. and Asia-Pacific region.” SVIEF has expanded to hold two conferences per year, the main conference held in the fall of 2016 and Silicon Valley Smart Future Summit held in winter and focused on interconnected devices. Both events are held at the Santa Clara Convention Center in Silicon Valley. A U.S. Congresswoman (Judy Chu) is the honorary Chairwoman of SVIEF and a keynote speaker at the principal fall conference was former U.S. Secretary of Energy Steven Chu. This gathering of startup CEOs, venture capitalists, Chinese companies and Chinese venture capitalists makes this an ideal location to collect information on the state of U.S. technology. Chinese officials attend who are assigned to collect intelligence.
2. **DEMO China**, an annual event held in Santa Clara, California (the heart of Silicon Valley) showcasing promising startups to Chinese investors. The event includes a keynote by the Chinese Consulate General, and has panels throughout the day covering topics such as navigating obstacles to investment in the U.S. and China; tips on how to evaluate startups; advantages of technology accelerators; and discussion of other investment trends.
3. **Silicon Valley-China Future Forum** (August, 2016) to link Silicon Valley with Chinese capital specifically in the fields of augmented reality, virtual reality and artificial intelligence.
4. **China Silicon Valley** is working with Silicon Valley city governments to drive increased investment and job growth by facilitating talent, technology and business exchange and investment between cities and businesses in China and their Silicon Valley counterparts. The intent is to help provide a one-stop service for government relations, legal, tax, consulting, networking and talent acquisition to facilitate Chinese government, businesses and individuals to invest, establish a factory, R&D center or other business activities in Silicon Valley. China Silicon Valley has an extensive network of business partners from diversified industries in Silicon Valley to carry out these activities.
5. **The Global Chamber San Francisco (GCSF)** hosts a seminar for entrepreneurs, investors and service providers with an interest in U.S.-China markets on strategies and best practices to enter and capitalize on business opportunities in U.S. & China.
6. **U.S.-China VC Summit & Startup Expo** (October, 2016) hosts a conference in Boston for investors and entrepreneurs who want to collaborate on opportunities between the U.S. and China.
7. **Chinese American Semiconductor Professional Association (CASPA)** holds many dozens of events per year in Silicon Valley and China. For 2017, the published schedule includes 4 conferences, 4 tradeshows, 4 workshops, 3 career development events, 3 international trips to China, hosted delegations from China and 6 members networking events. These events are all gathering Chinese and American semiconductor talent with the purpose of recruiting American talent.



Appendix 10: Strengths and Weaknesses of CFIUS Process Today

Strengths

- An understood process defined by FINSA statute (2007)
 - No clear view on what constitutes a controlling interest that triggers an assessment by CFIUS which allows CFIUS to review more transactions than if a quantitative metric were always applied such as a 51% equity stake
 - Many problematic potential acquisitions by Chinese companies have been stopped
-

Weaknesses

- CFIUS reporting is voluntary--transactions do not have to be reported
- There are many types of technology transfer not currently covered by CFIUS
 - Joint ventures where the U.S. company contributes IP/technology rather than an entire business
 - Technology licenses
 - Private company transactions that are "below the radar"
 - Minority investments that do not rise to the level of a "controlling interest"
 - Reverse mergers
 - Greenfield investments
 - Assets purchased from bankruptcies
- There's an inherent bias to develop mitigation agreements¹⁰⁸ to allow transactions to proceed but mitigation agreements are difficult to construct and enforce. Mitigation agreements lock companies into uncompetitive cost structures; these are too often designed under time pressure resulting in one-of-a-kind agreements or agreements which are far too comprehensive. There are no government resources assigned to monitor these agreements which undoubtedly means they are unenforced. The likelihood of a costly mitigation agreement also reduces the incentive for friendly foreign companies to acquire U.S. companies.
- There is no formal risk-scoring (by country and by sector) to create a transparent, scalable process to manage large numbers of transactions; expecting consensus among the 14 CFIUS agencies is unrealistic

¹⁰⁸ Mitigation agreements incorporate conditions that satisfy the national security risks such as governance measures, security requirements, separating a sensitive operation from the transaction or monitoring/verification mechanisms. From 2009-2011, roughly 8% of all cases reviewed resulted in mitigation agreements. "Understanding the CFIUS Process," Organization for International Investment.



- Security agencies (Department of Defense, Department of Justice, Department of Homeland Security) are not tasked to collaborate in articulating the national security risks of foreign investment in sensitive technology and facilities
- No comprehensive view of the technology landscape exists, and since CFIUS is only designed to review a single deal at a time, there is increased risk of damaging a complete sector critical to national security such as is happening in semiconductors¹⁰⁹
- Allied governments' view of threats are not incorporated
- Required certification to Congress of "no unmitigated security threats" is unrealistic; with an increasing number of complex transactions there will be unmitigated security threats that evolve
- 90-day timeline defined by statute does not allow for dealing with more complex transactions
- CFIUS transactions are expanding to >150/year and there is no dedicated funding by Congress to support this effort; resources are stretched in every participating agency

¹⁰⁹ "Ensuring Long-Term U.S. Leadership in Semiconductors," President's Council of Advisors on Science and Technology, January 2017



About the Authors



Michael Brown is a White House Presidential Innovation Fellow working with DIUx.

Through August of 2016, Michael was the CEO of Symantec Corporation, the global leader in cybersecurity. During his tenure as CEO (2014-16), he led a turnaround as the company developed a new strategy focused on its security business, sold its Veritas business, hired a new executive team, formed business units, improved operating margins and articulated a new culture fostering innovation. Michael served on the Symantec Board from 2005 until 2016.

Michael is the former Chairman and CEO of Quantum Corporation (1995-2003), a leader in the computer storage industry specializing in backup and archiving products. As CEO of Quantum, the company achieved record revenues as the world's leader in disk drives for PCs and the world's largest tape drive business. Michael joined Quantum in 1984 and served in various management roles before being named as CEO in 1995. Michael served on the Quantum Board from 1995 until 2014.

Michael has also served as the Chairman of EqualLogic and Line 6 and has served on the public boards of Nektar Therapeutics, Maxtor Corporation, and Digital Impact. He serves on the Board of Trustees of the Berklee College of Music in Boston. He has a BA degree in economics from Harvard and an MBA from Stanford University.



Pavneet Singh has served in several roles on the National Security Council and National Economic Council at the White House and is a consultant with DIUx.

Most recently, he served as director of international affairs and managed the U.S.-China and U.S.-India economic relationships including serving as the NSC's lead director for the Asia Pacific Economic Cooperation (APEC) Leaders' Summit in Beijing and developing the President's economic deliverables for the bilateral summit with Chinese President Xi Jinping.

From 2011 to 2013, Pavneet was the senior advisor to the Deputy National Security Advisor Mike Froman and provided strategic and policy guidance across a portfolio that included trade, energy, climate, exports and managing the U.S. economic relationships with emerging economies. Prior to the White House, Pavneet worked as an analyst at the World Bank and at the Brookings Institute. Pavneet earned his master's with distinction in international relations at Georgetown University and his undergraduate degrees in business administration and political economy from UC-Berkeley.

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