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Chinese Innovation

China's Technology Future and What It Means for Silicon Valley

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Acknowledgments

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About the Institute

Since 1990, the Bay Area Council Economic Institute has been the leading think tank focused on the economic and policy issues facing the San Francisco/Silicon Valley Bay Area, one of the most dynamic regions in the United States and the world's leading center for technology and innovation. A valued forum for stakeholder engagement and a respected source of information and fact-based analysis, the Institute is a trusted partner and adviser to both business leaders and government officials. Through its economic and policy research and its many partnerships, the Institute addresses major factors impacting the competitiveness, economic development and quality of life of the region and the state, including infrastructure, globalization, science and technology, and health policy. It is guided by a Board of Trustees drawn from influential leaders in the corporate, academic, non-profit, and government sectors. The Institute is housed at and supported by the Bay Area Council, a public policy organization that includes hundreds of the region's largest employers and is committed to keeping the Bay Area the world's most competitive economy and best place to live. The Institute also supports and manages the Bay Area Science and Innovation Consortium (BASIC), a partnership of Northern California's leading scientific research laboratories and thinkers.

Contents

This report was developed to shed light on a topic that will increasingly impact the US and world economies in the years to come: Is China innovative? Many continue to believe that China is adept at copying foreign technologies, but is not yet a technology and innovation leader. We found that this is an outdated perspective and that the course taken by China's technological capacity in the coming years will profoundly impact not only competition and market opportunities in China, but global competition as well. Understanding that trajectory—and its sources—is therefore critical not only to the United States and other trade and investment partners, but particularly to Silicon Valley, the leading US and global center for technology, innovation, and entrepreneurial activity.

This report assesses the public and private contributors to China's technology innovation and deployment and how they work together to accelerate China's capacity in strategic areas. It also maps China's current activity in the Bay Area in technology research, investment, and startups. The Institute's study parallels another report, *Chinese Direct Investment in California: 2017 Update*, produced by the Rhodium Group for the Asia Society of Northern California, on China's growing investment in California. That report covers all forms of investment, including mergers and acquisitions and greenfield investment in technology companies. The two studies have been developed together to shed new light on China's technology future and the role that California and Silicon Valley play. How that relationship develops will have profound implications not only for US-China trade and investment, but for the future relationship of the world's two largest economies.

Executive Summary

The shift in China's economy from low-end manufacturing to the production of increasingly sophisticated goods and services raises a far-reaching question: Is China innovative? Since innovation is widely viewed as being critical to technological competitiveness, the answer has important implications for Silicon Valley and other US technology companies. Its significance extends not just to trade but to investment as well, as US companies continue to invest in China, and Chinese technology companies increasingly invest in the Bay Area and California.

Innovation refers to the ability to produce new economic value through the creation or improvement of products or business services. It can take many forms. At one end of the spectrum is transformational innovation—something that fundamentally alters a market or an industry. Often, but not always, it is based on scientific research. But innovation can also be incremental—a modification or enhancement to an existing product or service that improves its market position and increases its economic value.

Understanding Chinese Innovation

China has advanced far beyond the mere copying of Western products or technologies and now excels at incremental innovation. It still lags the US, Europe, and Japan in transformational, science-based innovation, but with a sustained policy focus and investment by its government and the leverage provided by a massive domestic market, transformational innovation can also be expected to advance.

Government investment in scientific research is growing, as is the volume and quality of Chinese generated patents and articles published by Chinese authors in scientific journals. China is still playing catch-up when it comes to engineering, but quality is improving there as well. It can also devote large numbers of engineers to achieving its objectives. China also draws significantly on returnees from the United States and Europe, who have training and experience at Silicon Valley and other companies and universities and bring their knowledge home.

Advances are clear at the national level, in fields such as supercomputing, quantum communications, space, and robotics. In the private sector, advances can best be seen in mobile commerce, where China currently leads the world. While the innovations driving China's commercial success are mostly incremental, they are increasingly enabled by investment in artificial intelligence (AI). Outside of mobile commerce—in fields such as semiconductors, software, commercial aircraft, and life sciences—China's advance is more uneven. Even in those sectors, however, sustained investment is likely to bring change.

Leading Regions Concentrate Innovation Assets

China's innovation assets—leading private companies and public and private research centers—are primarily (but not exclusively) concentrated in three regions: Shenzhen and the Pearl River Delta, Shanghai and the Yangtze River Delta, and Beijing. Companies headquartered in those regions—Huawei in ICT, Tencent and Alibaba in internet and e-commerce, DJI in drones, Broad Group in construction, Geely in automobiles, and Mobike in bike sharing—exemplify the innovation that is taking place across a range of industries.

These companies dominate the Chinese market and are looking to global markets overseas for expansion. Products and services developed in Chinese markets don't always transfer well outside China.

China also has an increasingly robust startup scene, with a rapidly growing number of incubators and accelerators. Many are sponsored by provincial and city governments, offering benefits such as grants or free rent. It is not clear, however, whether their rapid expansion reflects a similar scale of innovation, or whether it constitutes a bubble.

There is also growing private investment in startups, by large companies such as Tencent, Alibaba, and Baidu, and through an array of venture capital and private equity firms. Reflecting the scale of this activity, in 2016

China led Asia in the production of unicorns (companies with valuations of $1 billion or more) with 37; the country with the next largest number was India with 8. Internet companies are receiving more than half of China's venture deal flow, and of China's 46 unicorns in 2017, nearly half are backed by China's largest internet companies.

Still, China's startup support ecosystem remains a work in progress. Venture investors often look to monetize their investments quickly, reinforcing tendencies in their portfolio companies to go for short-term gains instead of transformational leaps (an area in which Silicon Valley excels). Most Chinese universities are also behind the curve when it comes to programs that generate and support entrepreneur-led startups.

Government Policies

To a degree that far exceeds other major economies, China's technology development trajectory is deeply connected to government through a web of industrial policies set by the Communist Party, whose influence extends beyond provincial and local governments and state owned enterprises (SOEs) to private companies as well. This happens directly through embedded Party representatives and through incentives and disincentives that encourage private companies to align with government priorities. The most important policies impacting technology and innovation are the 13th Five Year Plan; Made in China 2025; the National Medium- and Long-Term Program for the Development of Science and Technology 2006–2020; the National Innovation-Driven Development Strategy Outline; the National Security Law; the National Cybersecurity Strategy; and the Social Credit System.

In the aggregate, these policies promote national corporate champions, "indigenous innovation" (the increased development of Chinese technology and reduced reliance on technologies of non-Chinese origin), and a transition to making both domestic and imported data systems "secure and controllable." Required technology transfer to local partners by foreign companies investing in China, and the Great Firewall (which restricts access inside China to information provided by non-Chinese internet companies), advance these laws and policies. Weak but improving intellectual property protection adds to the challenge that both foreign and Chinese companies face.

In the process of supporting domestic innovation and security, these policies also create advantages for Chinese technology companies and disadvantage foreign ones. But this tilted playing field can also inhibit innovation through a too-heavy government hand and by restricting the free flow of ideas and information on which innovation thrives.

China and the Bay Area

China and the Silicon Valley/San Francisco Bay Area are closely connected through technology and innovation, a relationship that is growing stronger through inbound investment. California is the primary destination in the US for China's outbound technology investment, most of which has been received in the last two years. The lion's share of this is through acquisitions, primarily in ICT (Information and Communications Technology) concentrated in Silicon Valley, and spread across semiconductors, ICT equipment, and software. Investment in biotechnology is also significant. This investment comes primarily from private as opposed to state-owned companies. Government funds, however, are also used to fund acquisitions.

Leading Bay Area companies such as Uber, Lyft, and Airbnb have received substantial infusions of capital from China, primarily through Chinese participation in funding rounds. Many startup and early-stage companies have also received funding. Typically, Chinese investors in these smaller companies look for cutting edge technologies to fill competitive gaps in China. For the startups, Chinese investment brings not just capital but better access to Chinese markets. This activity is supported by a growing number of Chinese accelerators, corporate innovation centers, and venture funds that have opened in the region.

Looking to the Future

There is no question that China is innovative. This is evident in its leading private companies, which are among the best in the world in their fields. The question of innovation is complicated, however, by the role of China's government which, to a degree unseen in market economies, directs resources, supports domestic technology companies, inhibits foreign ones, and mandates technology transfer. Under its policies, every player in China's economy—public or private—is ultimately linked to national objectives. This presents complex options for US technology companies that want access to China's growing market but do not want to risk their technology being lost or compromised. It also raises issues regarding the long-term impact of China's technology investment in the US.

Chinese companies are demonstrating increased prowess in leveraging China's market scale, government support, foreign technology, and their own R&D to generate innovation-led growth. While most SOEs and smaller companies still lag, the best Chinese companies can be strong partners, as well as formidable competitors. As China's already considerable innovative capacity grows, this will present both challenges and opportunities for Bay Area/Silicon Valley companies. Either way, every company will need a China strategy or a global strategy that takes China into account. With the right conditions, both sides can benefit from an open door. Business decisions and government policy will determine whether China's technology trajectory leads to increasing conflict or to expanded partnerships between the world's two largest economies.

Introduction

As China's economy has grown to become the world's second largest, with predictions that it will become the largest by 2030, its structure has advanced. In less than three decades, China's GDP has risen from $347.8 billion in 1989 to $11.2 trillion in 2016.[1] Much of that growth has been built on internal investment, particularly in infrastructure and the construction or reconstruction of cities needed to support rapid urbanization. The second pillar of China's growth has been manufacturing and the development of massive supply chains that have enabled companies from around the world—including the United States—to cost-effectively produce or source manufactured goods. Often this has involved establishing production facilities or supplier networks in China, producing for overseas markets initially, but increasingly for Chinese markets as well. In the process, foreign direct investment (FDI), which came to China on a massive scale, became a key contributor to China's growth surge.

Initially, Chinese production was focused on low-tech products such as toys and textiles, produced with low cost labor. More recently, however, that production has scaled up to progressively higher levels of quality and sophistication. This evolution has paralleled the development of China's own (increasingly wealthy) domestic market, encompassing both consumer goods and technology products.

This raises a question: What is China's technology trajectory and, if current trends continue, where will China be on the map of global competition in the future? At a deeper level, there is another question: Is China innovative? The competitiveness of advanced economies is increasingly based on their capacity to innovate. This holds for companies of all sizes, and at a larger level for nations, as they strive to create the conditions that will enable scientific and business innovation. It is particularly true for technology which, in its rapid advance, is creating winners and losers at an accelerating pace. Companies that innovate define their industries, leaving behind competitors with legacy technologies or business models. The capacity to innovate is therefore critical to global competitive advantage.

Many still believe that China's economy is built on cheap labor and the copying of Western technologies. Others call China a "fast follower," not leading in innovation but successfully adopting and adapting innovations that started elsewhere. But is that true? This report assesses the state of technology development in China today, and specifically China's internal capacity to innovate. The answer has important competitive and policy implications for the United States and particularly for Silicon Valley, which today is the world's leading center for technology and business innovation and a critical platform for entrepreneurial activity in both digital technology and life sciences.

Defining "Innovation"

There is no standard definition of innovation. Broadly speaking, however, it refers to the ability to produce new economic value through the improvement of products or business processes. It can come in many forms. At one end of the spectrum is innovation that is transformational—something that fundamentally alters a market or an industry. Often, but not always, this grows out of scientific research or an investment in R&D. But innovation can also be incremental—a modification or enhancement to an existing product or service that improves its market position and increases its economic value. Essentially, the difference is between invention and improvement. Both are important and need to be understood on their own terms.

The Bay Area/Silicon Valley, for example, excels at transformational innovation. The region's institutional research infrastructure—led by Stanford and four University of California campuses (Berkeley, San Francisco, Santa Cruz and Davis), five federal laboratories, and a multitude of non-profit and corporate laboratories—makes the region a magnet for the funding of research, much of which is licensed by entrepreneurs to produce new commercial products. The region's venture capital industry, the world's largest, fuels that transition with an unmatched record of turning ideas into products. An open environment that reduces barriers to collaboration and supports the flow of ideas and information is another enabler. Google, Facebook, Intel, Apple, Genentech, Tesla, Uber, LinkedIn, and Airbnb (to name just a few) exemplify how the Bay Area and Silicon Valley lead the world in transformational innovation.

Incremental innovation and business model innovation are also important, however, particularly in moving existing markets to higher levels of productivity and profitability. When considering the question of innovation in China, then, it is important to look at the full innovation range: transformational, business model, and incremental.[2]

Understanding Chinese Innovation

In the last two decades, China has advanced from a business model based on copying Western products to one that increasingly embraces innovation, produces new value, and creates market leaders. Chinese companies have proven adept not just at copying Western products, but at adapting them and lowering costs to fit the Chinese market. This is producing incremental innovation that goes beyond simple imitation to create new market value. Increasingly, technology is an enabler and is amplifying the impact.

China's government has embraced technology innovation as a priority; at the October 2017 Chinese Communist Party Congress, which is looked to as a key source for future policy direction, President Xi Jinping called on China to be a country of innovators, particularly in the frontier areas of science and technology, setting the goal of China becoming a top-ranked innovation nation by 2035.[3] As part of that vision, Xi indicated that China will strengthen basic research in applied science, invest in the production of a larger number of leading scientists, launch major national science and technology projects, and prioritize innovation in key generic, emerging, and disruptive technologies.[4]

Innovation Inputs: Science and Engineering

While not definitive on the question of innovation, several metrics are indicative of China's technological development and its capacity to marshal resources in order to innovate at the national level.

Government Funding for Scientific Research

As will be detailed below in the discussion on government policy, China's government is committed to advancing the country's scientific capacity. In 2000, China devoted .89% of its GDP to R&D, a number that grew to 1.31% in 2005 and 2.07% in 2015. Though it starts with a much higher base, the comparable figures for the United States are 2.62%, 2.51%, and 2.79%.[5]

A breakdown of spending patterns shows that while the US continues to lead in basic and applied R&D investment—with about one-third of its $500 billion annual spending going into early-stage discovery research and two-thirds into later-stage "development"—China allocates 84% of its R&D spending to later-stage research connected to commercial products. According to the Boston Consulting Group, in the past decade this "development" R&D has been growing at about 5% per year in the US, compared to around 20% per year in China.[6] As recently as 2004, the US spent four times as much as China on similar research. At its current rate of spending, China is on track to invest twice as much as the US, or $658 billion, in this late-stage research by 2018.[7] In other words, while committed to increasing the absolute level of funding for scientific research, in comparison to the US, China is less oriented toward deep (discovery) research and more focused on capturing the value of scientific research for commercial purposes. This has implications for the kind of innovation at which China excels—incremental as opposed to science-based.

Chinese Share of Articles Published in International Scientific Publications

China has vastly increased its output of scientific articles since the start of the millennium. In 2013, 18.2% of all scientific articles were Chinese in origin, nearly triple its 6.4% share just a decade earlier. By comparison, the US share was 18.8%, a decline from 26.8% a decade earlier and approximately the same as China's; so by 2013, measured by raw output of scientific articles, the two had achieved parity. More than a third of China's scientific papers were in engineering and 21% were in life sciences, with chemistry, physics, and computer science the next largest categories. In comparison, half of all papers in the US were in life sciences and 12.4% were in engineering.[8]

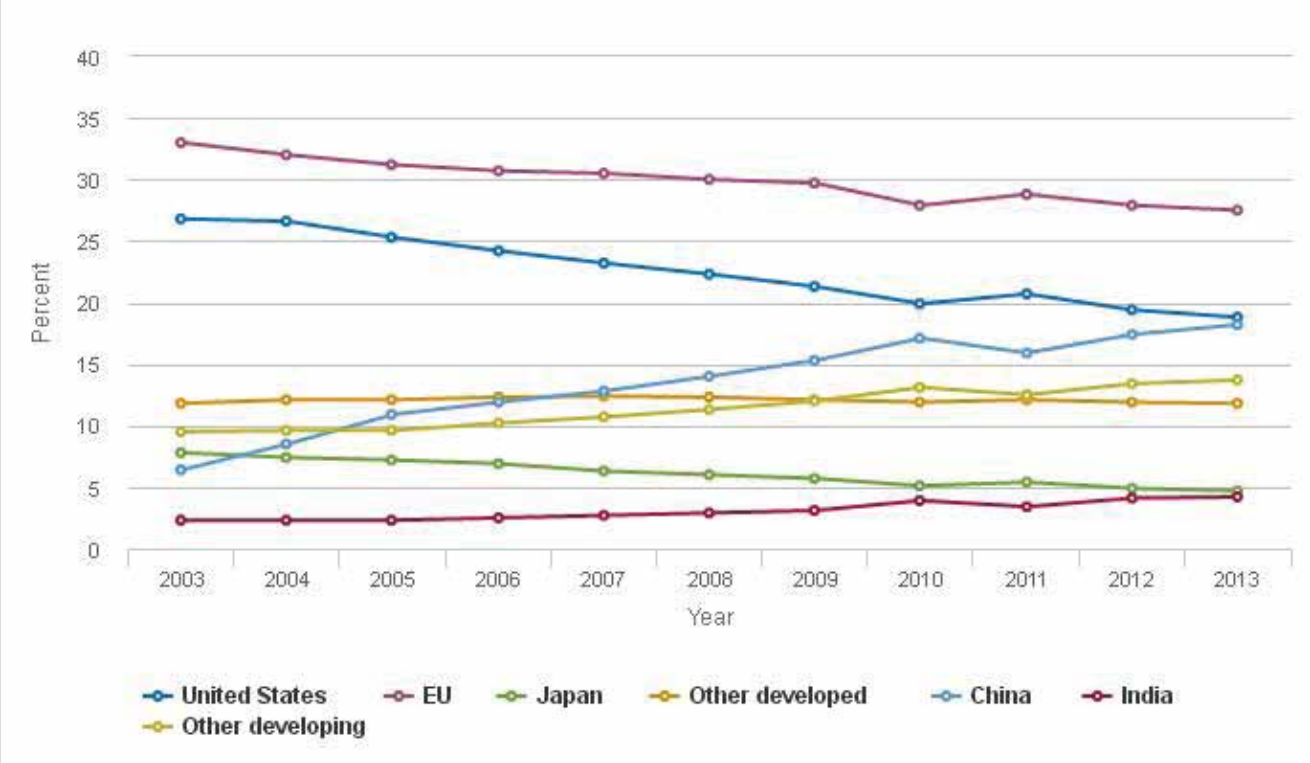
However, while impressive, these raw numbers tell little about the quality of scientific research. One criticism of the current Chinese system is that research universities hire large numbers of postdocs, which sharply increases the number of scientific papers being produced. While yielding impressive statistics, this doesn't necessarily reflect high quality or innovative output. A look at *cross-national citations* in international scientific publications gives a better indication, but in China's case has limitations due to language and other barriers.

Between 1996 and 2012, citations of Chinese science and engineering papers in publications outside China actually fell, suggesting that the output of most Chinese science and engineering publications is being used primarily inside China and cited in Chinese language publications. Between 1996 and 2012, by comparison, the US share of international citations grew from 42.8% to 54.5%.[9]

National Science Board Science & Engineering Indicators: Publication Output

Figure 5-24

S&E articles, by global share of selected region/country/economy: 2003–13



EU = European Union.

NOTES: Publication counts are from a selection of journals, books, and conference proceedings in S&E from Scopus. Publications are classified by their year of publication and are assigned to a region/country/economy on the basis of the institutional address(es) listed in the article. Articles are credited on a fractional-count basis (i.e., for articles from multiple countries/economies, each country/economy receives fractional credit on the basis of the proportion of its participating authors). Some publications have incomplete address information for coauthored publications in the Scopus database and cannot be fully assigned to a country or economy. These unassigned counts, 1% of the world total in 2013, are used to calculate this figure but are not shown. See appendix table 5-26.

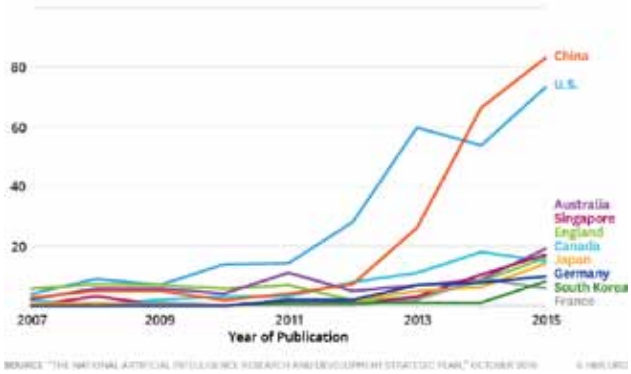
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics; SRI International; Science-Metrix; Elsevier, Scopus abstract and citation database (www.scopus.com).

Science and Engineering Indicators 2016

Source: National Science Board, *Science & Engineering Indicators, 2016*, Chapter 5, p. 5-96

China Is a Leader in AI Research

Number of journal articles mentioning "deep learning" or "deep neural network" and cited at least once by another publication



Source: Arjay Agrawal, Joshua Gans, and Avi Goldfarb, "The Obama Administration's Roadmap for Ai Policy," *Harvard Business Review*, December 21, 2016, <https://hbr.org/2016/12/the-obama-administrations-roadmap-for-ai-policy>

Another and perhaps better measure is the representation of a nation's research in the top 1% of most cited papers. The National Science Board scores nations' representation in this category, normalized so that a score of 1 indicates that a nation's work is in the top 1% as often as would be expected based on publication volume. In 2002, China's score for all fields was .5; ten years later its score had risen to .8. China's score particularly improved in engineering (from .52 to .73), computer science (.21 to .8), and chemistry (.61 to 1.3). In the same period, the US score in all fields increased from 1.76 to 1.94.[10] This suggests two things. First, the quality of China's scientific research has improved significantly. Second, China's share of top 1% articles is still 20% smaller than would be expected given its total production of scientific papers.

The Nature Index—which is produced by the scientific journal *Nature* and counts articles published in a group of 68 prestigious life and physical sciences journals—offers another measure of research quality. China placed second in both 2012 and 2016. In 2012, its article count was 24% that of the US, which came in first; in 2016 its article count was about 38% of that of the US.[11]

It should be noted that a growing amount of scientific research today is based on international collaboration, and China also does well in this category. National Science Board data indicates that US authors collaborate most frequently with counterparts from China, which accounted for 18.7% of US internationally co-authored publications in 2013. This placed China ahead of the United Kingdom (12.7%), Germany (11.8%), Canada (10.4%, France (7.8%), Italy (6.7%) and Japan (5.9%).[12]

This and other reporting suggests that China today is capable of producing not only a high quantity of scientific research, but high quality research as well, and that its capacity is increasing. This is particularly evident in the field of artificial intelligence (AI), which China is prioritizing. In the last five years, the US and China both grew their research output in AI significantly faster than other countries, with the US the initial leader. In the last three years, however, China has overtaken the US.

Scientific and Engineering Talent

China is still playing catch-up when it comes to engineering talent. Despite China's production of engineers in large numbers, top-level talent is still hard to find there compared to the United States. The artificial intelligence field offers an example where high-end talent in private companies is thin, and AI only recently became a priority at China's research universities. As a result, Chinese companies often draw on Chinese-born engineers in the United States, many of whom are graduates of US universities or have worked on big-data infrastructure at companies such as Google or Facebook. This also includes Chinese students who return home after studying in the West—a large and rich base. Known colloquially as "sea turtles," their ranks include Baidu founders Robin Li and Eric Xu; Gary Wang, founder of the online video sharing service Todou.com; and Qian Xuesen, the father of China's space program. According to Huiyao Wang, vice chairman of the China Western Returned Scholars Association and senior advisor to the central government,

> 78% of the university presidents, 63% of PhD advisers in Chinese universities administered by the Ministry of Education, and 72% of the directors of key national and provincial laboratories are returnees;
>
> more than 260 startup parks have been developed across China to accommodate returnees;
>
> most Nasdaq-listed Chinese companies are either funded or run by returnees; and
>
> 57% of businesses started by returnees are in scientific fields, with 44% holding patents.[13]

In recent years, the number of overseas Chinese students choosing to return home after graduation has grown. A 2007 analysis by the Chinese Academy of Social Sciences found that only a quarter of students who studied abroad from 1978 to 2006 returned.[14] By 2013, a Chinese recruiting agency survey found that 72% of students studying overseas planned to return.[15] (At that time about 214,000 Chinese nationals were studying at all levels in US institutions.)[16] Today, according to China's Education Ministry, 80% of Chinese students studying abroad are returning.[17] In the early days, most went to work for multinational corporations and universities, but today a growing number are working for large Chinese companies or are starting their own.

Behind these numbers are trends that paint a somewhat more nuanced picture. In the 1990s, when large numbers of Chinese students began coming to the US, there was little economic opportunity in China so most elected to stay. Many became embedded in the Silicon Valley ecosystem, where in any given year immigrants from China make up either the largest or second largest number of immigrant company founders. (This is significant, since nearly half—43.9%—of tech company founders in the Valley come from overseas.)[18]

Historically, these students were heavily concentrated in the graduate departments of research universities, studying fields such as engineering or computer science. Today, a growing number are coming at the undergraduate level, to a wider range of colleges and universities. This reflects the growing spending power of China's middle class and their desire to have their children receive a Western education. This shift affects the aggregate impact of returnees, whose average quality may be lower than in the past, even as the quality of science and engineering graduates generated inside China is increasing. Most graduate-level students coming to the US still choose to remain after receiving their degrees, but for shorter periods than in the past. For doctoral students, the 2015 Survey of Earned Doctorates published by the National Science Foundation found that more than 80% planned to remain in the US after receiving their PhDs.[19] Overwhelmingly, these degrees are in science and engineering, accounting for 4,979 of the 5,384 doctorates awarded to Chinese nationals by US institutions.[20] To draw more of these senior-level graduates home, the central government has created the Thousand Talents initiative, promising jobs at R&D facilities and SOEs (state owned enterprises), and special living benefits.[21] So far it has been a success, attracting high-level talent not just from universities but from top tier companies as well.

Patents

Particularly since 2010, China has greatly increased its production of patents: the 12th Five Year Plan, which ended in 2015, targeted 3.3 patents per 10,000 people, but double that number was actually achieved (6.3 per 10,000).[22] The largest number of inventions covered by patents in 2016 was in digital computer technology, including data transfer across networks, data processing systems, and database software applications. The vast majority of patented inventions from Chinese organizations are protected for the local market only, but companies are increasingly looking to protect their innovation in global markets as well. ZTE leads the pack with 66% of their 2012–2016 invention portfolio filed outside China, followed by Huawei (65%, AMEC (63%), and Alibaba (56%). All are leading players in the electronic components, consumer electronics, and media internet industries, reflecting China's growing influence and impact in these areas.[23]

Another metric of patent quality is the conversion rate from patent applications to patent grants. In 2017, this number fell 4.9%, but counterintuitively this may indicate an improving environment, as it may reflect strengthening patent quality, as standards by both filers and regulators increase. A final metric is the rate of citations of inventions in later published patents (i.e., the higher the quality of a patent the more likely it is to be picked up and developed by other innovators). The metric used in this area is the ratio of citations per patent family to the total number of patent families, representing "influence." In 2016, this metric for China's most innovative companies and organizations grew by an impressive 60%. China's performance in this area is not yet up to global standards, however. While China has an average ratio of .85 citations per patent family, the average ratio for the top 100 global innovators is 1.12.[24]

Technology Parks

Though not necessarily indicators or enablers of innovation, China's technology parks provide a critical part of the infrastructure on which its technology capacity is built, concentrating production and research in designated areas. Today there are roughly 100 science and technology parks in China.[25] Of these, 54 are sponsored by the national government and the rest by local governments. Official science and technology parks with national sponsorship receive a variety of tax and regulatory benefits; within the parks, the national Torch Program administers R&D projects. China's first tech parks were developed in the 1980s, with the first being Zhongguancun Park in Beijing, which received national status in 1988.[26] Another of the early state-level parks, established in 1992, is the Zhangjiang Hi-Tech Park in Shanghai, which currently houses over 3,600 companies and 100,000 workers.[27]

National Science and Innovation Capacity: Indicative Sectors

With growing talent, sustained investment in R&D, and focused policy initiatives, China has developed the technological capacity at a national level that enables it to take on large, ambitious goals. Some particularly noteworthy examples include the following.

Supercomputing

In 2016, China revealed a new supercomputer, the first developed entirely with processors designed and made in China, which currently rank as the world's most powerful. Before that, China's Tianhe-2 computer had held the title of world's fastest computer for three years but was built using Intel processors and an interconnect chip designed in China. The new system is five times faster than the top-ranked US computer (at Oak Ridge National Laboratory). These advances have been supported by sustained government investment. Jack Dongarra, who compiles the twice-yearly Top 500 ranking of global computers, gives this perspective: "In 2001 there were no supercomputers listed on the Top 500 in China. Today China has 167 systems on the list compared to 165 systems in the US. This is the first time the US has lost the lead…It is clear that they are on a path which will take them to an exascale computer by 2020, well ahead of the US plans for reaching exascale by 2023."[28]

Quantum Communications

Quantum computing, which processes data exponentially faster than current computers, has a wide range of strategic applications, including encryption. Chinese scientists have succeeded in sending specially linked pairs of particles from space to Earth, a breakthrough that establishes China as a leader in efforts to harness energy and matter at the subatomic level. The experiment applied a phenomenon of quantum mechanics that allows two particles to be entangled so that whatever happens to one is immediately reflected in the physical state of the other regardless of the distance between them. Quantum encryption, a key target in China's 13th Five Year Plan (2016–2020), is considered secure because the information encoded in a quantum particle is destroyed as soon as it is measured, meaning that it will disappear if intercepted.

The ability to use quantum mechanics to create secure communications networks represents a significant advance in cryptography research and places China in a strong future position to develop an extremely hack-proof communications network. The US is also pursuing quantum communications but is concentrating more on quantum computing; European researchers are also working on quantum encryption, but their Chinese counterparts are better funded.[29]

In August 2016, China launched the world's first quantum communications satellite into orbit. Chinese physicist Pan Jianwei had returned from the University of Vienna to lead the project. In an interview with Chinese television Pan noted, "We've taken all the good technology from labs around the world, absorbed it, and brought it back"[30]—an indication of China's capacity to leverage science and innovation from other places and accelerate its development to meet strategic national objectives.

Space

China's space program is making major strides. It launched 21 successful orbital-launch missions in 2016,

just short of the US number of 22. It is the goal of the China National Space Administration (CNSA) to land rovers on the far side of the moon in 2018 and on Mars by 2020.[31] In 2016, China completed building the world's largest radio telescope and launched Shenzhou, its sixth manned space station. Plans target sending astronauts to the moon by the mid-2030s. In 2017, China's first cargo spacecraft was launched, which it will use to build its own space station by 2022.[32] According to Wu Yanhua, the Deputy Chief of CNSA, "Our overall goal is that, by around 2030, China will be among the major space powers in the world."[33] It is estimated that China currently spends around $6 billion a year on its space program, about $1 billion more than Russia, but far below the US's $40 billion.[34]

Robotics

China is now the world's largest market for industrial robots, accounting for 89,000 out of 290,000 sold globally in 2016. As China's domestic suppliers have moved up the supply chain to produce higher end products, they have increased their share of the domestic industrial robot market to 33%. Foreign-produced robots, however, still lead the markets in China's automotive sector (85%) and it 3C (computer, communication, and consumer electronics) sector (60%), although the market share of domestic robots in these sectors is growing. The government wants to increase the domestic annual output of industrial robots to 100,000 by 2020, as a key element in its drive toward higher-value advanced manufacturing.[35]

Electric Vehicles

As in the United States and Europe, conventional fuel vehicles still dominate the automotive market in China. The government's targets, however, call for 40% of cars sold in China to be pure electric or plug-in hybrids by 2030. Whether or not it hits that target, estimates suggest that as many as 32 million new energy vehicles (EVs) could be on the road by 2025. China is already the world's largest electric vehicle market, accounting for half of the 700,000 electric vehicles sold worldwide in 2016. EVs receive generous subsidies from the government and are also being subsidized by cities that are electrifying bus and taxi fleets. While foreign automakers, operating through joint ventures (foreign auto makers are required to establish joint ventures to produce cars in China or face a 25% import tariff), are actively building gasoline-powered vehicles in China and are planning to produce hybrid and all-electric vehicles in the future, nearly all electric vehicles sold in China today are produced by Chinese companies without foreign partners.[36] In a break with that pattern, Tesla—whose second largest Model 3 auto market after the US is China[37]—reached an agreement with government officials in October 2017 to build an all-electric vehicle in Shanghai. It will not, however, take on a Chinese partner, so cars sold in the Chinese market will be subject to the tariff unless Tesla can negotiate a special exemption.[38]

Artificial Intelligence

A national guideline issued by the State Council in July 2017 calls for China to make major breakthroughs by 2025 and become a global innovation center in artificial intelligence by 2030, with a targeted output value in AI industries of $148 billion. New industries using AI technology (such as advanced machine learning and quantum computing) are identified, and an open source computing platform and the incorporation of AI into traditional industries are promoted. Training and attracting more AI scientists and professionals is a priority, and multinational companies are encouraged to establish R&D centers to cooperate with Chinese enterprises.[39]

Not only the national government, but also provinces, cities, and leading Chinese companies are prioritizing artificial intelligence through investment and the aggressive incorporation of AI in corporate and strategic plans. As explained by Baidu CEO Robin Li, "when the age of AI arrives, the [internet of things] will become a big market and completely change manufacturing. I think that in the future all manufacturing will be a part of the AI industry…China is a manufacturing giant, and I think we need to really pay attention to AI tech development."[40] Baidu itself is aggressively building AI into its mobile search platform and is rapidly moving into autonomous vehicles, where its Apollo software system is aiming to have autonomous driving and entertainment technology in level-four cars (which are fully self-driving) by 2021.[41]

At the moment, China still lags the US in critical areas, such as basic research and AI scientific talent, and

lacks an AI industrial chain linking research institutions and companies. Innovation in core algorithms and high-end chips also falls short. But largely thanks to its large-scale commercialization of digital business models (see Mobile Commerce below) China is in a strong position to leverage the massive volume of data being generated by its internet users to commercially accelerate AI's applications. As its capacity inevitably grows, the government's plan for China to be the world leader in AI by 2030 is well within reach.

Innovation Dynamics

While government investment is playing a critical role in China's technological development, commercial innovation is happening primarily in China's private sector.

As George Yip and Bruce McKern describe in their book *China's Next Strategic Advantage,* most Chinese companies are pursuing incremental innovation. This is because their technical abilities often lag the US and other competitors, but also because China's market is growing fast and until recently Chinese companies have been competing to meet an almost unlimited demand for basic goods and services. In other words, there hasn't been a premium for disruptive innovation. That said, Chinese companies can be expected to develop a capacity for more radical innovation in the future, as their technological capacity grows and as domestic markets become saturated and domestic competition intensifies.[42]

Yip and McKern observe that Chinese companies seldom go for "moonshot" innovations, preferring instead pragmatic or incremental improvements that can sustain leadership in a market but not get too far ahead of it. Their success has been built on several factors, including the ability to inexpensively deploy large numbers of engineers and scientists against a problem, a readiness to move quickly and flexibly to address market opportunities, and an ability to effectively read and respond to Chinese consumer demand.[43] As their technical capacity increases, however, they will reach for more ambitious goals.

Overall, a 2015 McKinsey analysis found that Chinese companies have achieved significant innovation-led growth in consumer-facing industries (such as appliances, smartphones and e-commerce) and in efficiency-driven industries (such as solar panels, semiconductor foundries, generic pharmaceuticals, and industrial machinery). In engineering-based industries the evidence is mixed, with good metrics in products such as railroad equipment and wind power, but less success in products like automobiles and commercial aircraft. In science-based innovation (such as branded pharmaceuticals, biotechnology, and semiconductor design) China is still well behind its Western competitors. Where success has been achieved in these fields, it is linked to distinct characteristics of China's economy: customer-facing innovation is linked to the scale of its consumer market; efficiency-driven innovation is linked to the scale of its manufacturing ecosystem; and engineering innovation is linked to the demand created by government policy for products such as high-speed rail and wind power.[44]

Mobile Commerce

Scale particularly matters in e-commerce, driven by a massive smartphone user base that in turn is driving a growing investment in AI. The McKinsey Global Institute ranks China number three in the world for venture investment in key digital technologies, including virtual reality, 3D printing, robotics, drones, and artificial intelligence. China's e-commerce market, the world's largest, accounts for 40% of the worldwide value of e-commerce transactions, up from less than 1% a decade ago. The implications of this market scale can be seen in mobile payments, where China claims 11 times the transaction value of the United States.[45]

McKinsey attributes this growth in digital markets and capacity to three primary factors:[46]

1. A vast, young market that is enabling the commercialization of digital business models on a large scale. In 2016, China had 731 million internet users (more than half the population, and more than the United States and the European Union combined.) Ninety-five percent access the internet from their phones; nearly 20% rely on mobile only (compared to 5% in the US). The share of internet users in China making digital payments is 68% (compared to 15% in the US). This enthusiasm for digital tools in China creates a highly receptive environment for business model innovation.
2. China's three internet giants, Tencent, Alibaba and Baidu, are building rich digital ecosystems that touch

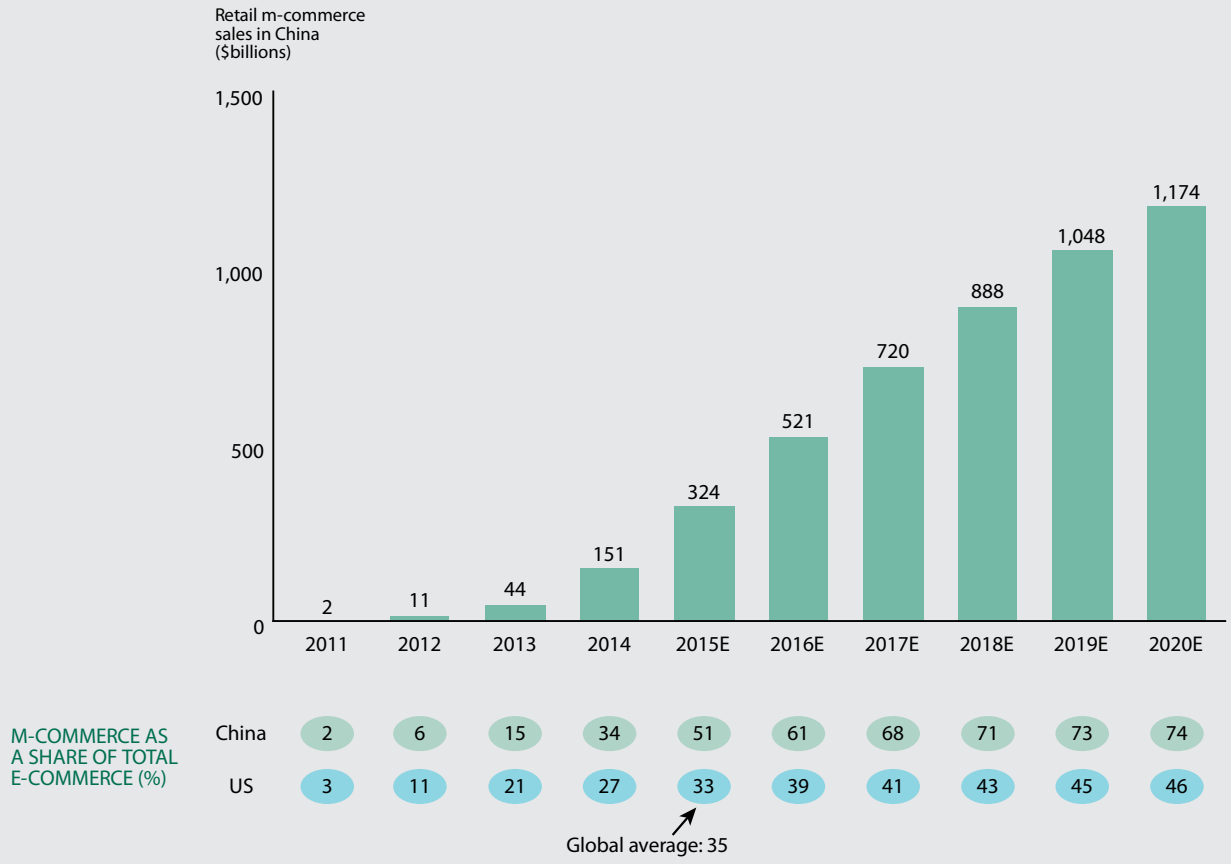
on almost every aspect of consumers' lives. This is supported by a high level of technical capacity and world-class computing efficiency.

3. The government is playing an active role building world-class infrastructure to support digitization.

China's rapid advancement in mobile payments is particularly striking. It is enabled by the relative absence of legacy brick-and-mortar stores, by the rise of brands that exist only online, and by the explosive growth of e-commerce. Most payments today are made by smartphone using Alibaba's Alipay or Tencent's WeChat. For many consumers these apps have become a virtual wallet. Data from Alibaba shows that 71% of payments made on its platform in 2016 were made by smartphone.[47] Nearly every business in China, including even the smallest vendors, is connected by phone or QR code.[48] This transaction scale enables China's internet companies not just to generate profits but to accumulate massive amounts of data—sourced from shopping sites, geo-location maps, financial services and social media—which can be further leveraged for commercial purposes.

China Is A Mobile Commerce Pioneer

Exhibit 2 | Mobile Commerce in China Is Growing Far Faster Than in the US



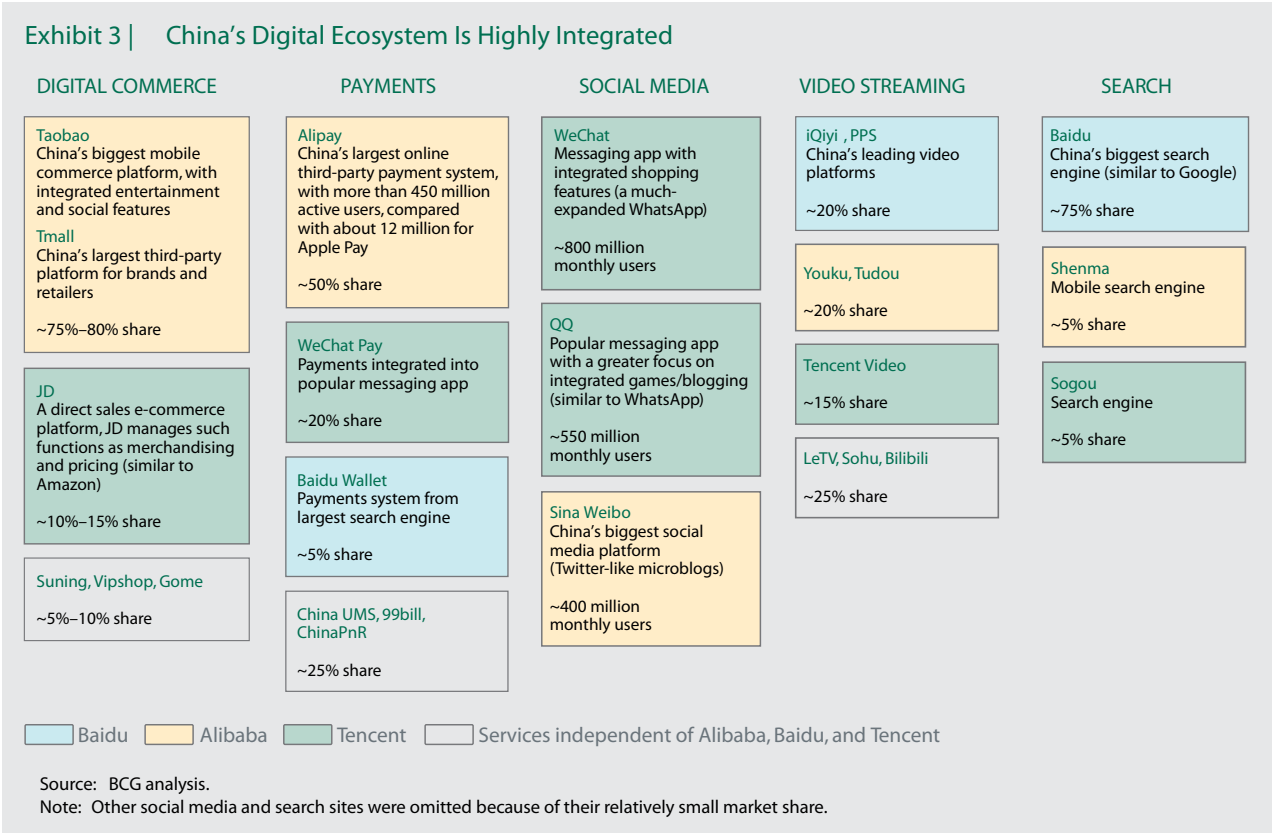
Sources: Criteo; iResearch; eMarketer; BCG analysis.
Note: Converted at an exchange rate of US$1=RMB6.24. M-commerce = mobile commerce.

Source: Chris Biggs et al., "What China Reveals About the Future of Shopping," The Boston Consulting Group and Alibaba Group, May 2017 <https://www.bcg.com/publications/2017/retail-globalization-china-reveals-future-shopping.aspx>

The pre-purchase, purchase, and post-purchase phases of transactions are often more seamlessly integrated than in the West, creating a more efficient and engaging online and offline consumer experience. Live streaming with well-known celebrities and experts is used extensively.[49] China's internet companies have proven adept at responding to consumer data quickly, driving consumer-to-business (C2B) innovation more than the business-to-consumer (B2C) innovation that is more common in the West.[50] This, in turn, is enabled by rapidly growing investment in AI, building on internal computing capacity and proprietary algorithms. Apart from the much smaller markets of Scandinavia, the adoption of mobile payments at this scale is a uniquely Chinese phenomenon.[51]

The mobile commerce phenomenon is stimulating innovation inside China, but the current model may face limits. As Chinese internet companies start to extend their reach outside the country's borders, it is not clear whether consumers elsewhere will adopt mobile payments at a similar scale or speed, or whether—being mostly customers of US internet companies—they will shift to Chinese service providers. And inside China, scale can be a two-edged sword. The dominant position of the three largest companies—Baidu, Alibaba, and Tencent, collectively known as BAT—may arguably inhibit innovation as they exert extraordinary influence on the startup landscape by acquiring and absorbing startups and potentially preempting disruptive innovation in emerging business sectors. According to McKinsey, the BAT companies accounted for 42% of all venture investment in China in 2016, a far stronger role than is played by US companies, such as Facebook or Google, that also invest in startups.[52]

E-Commerce in China is Seamlessly Integrated



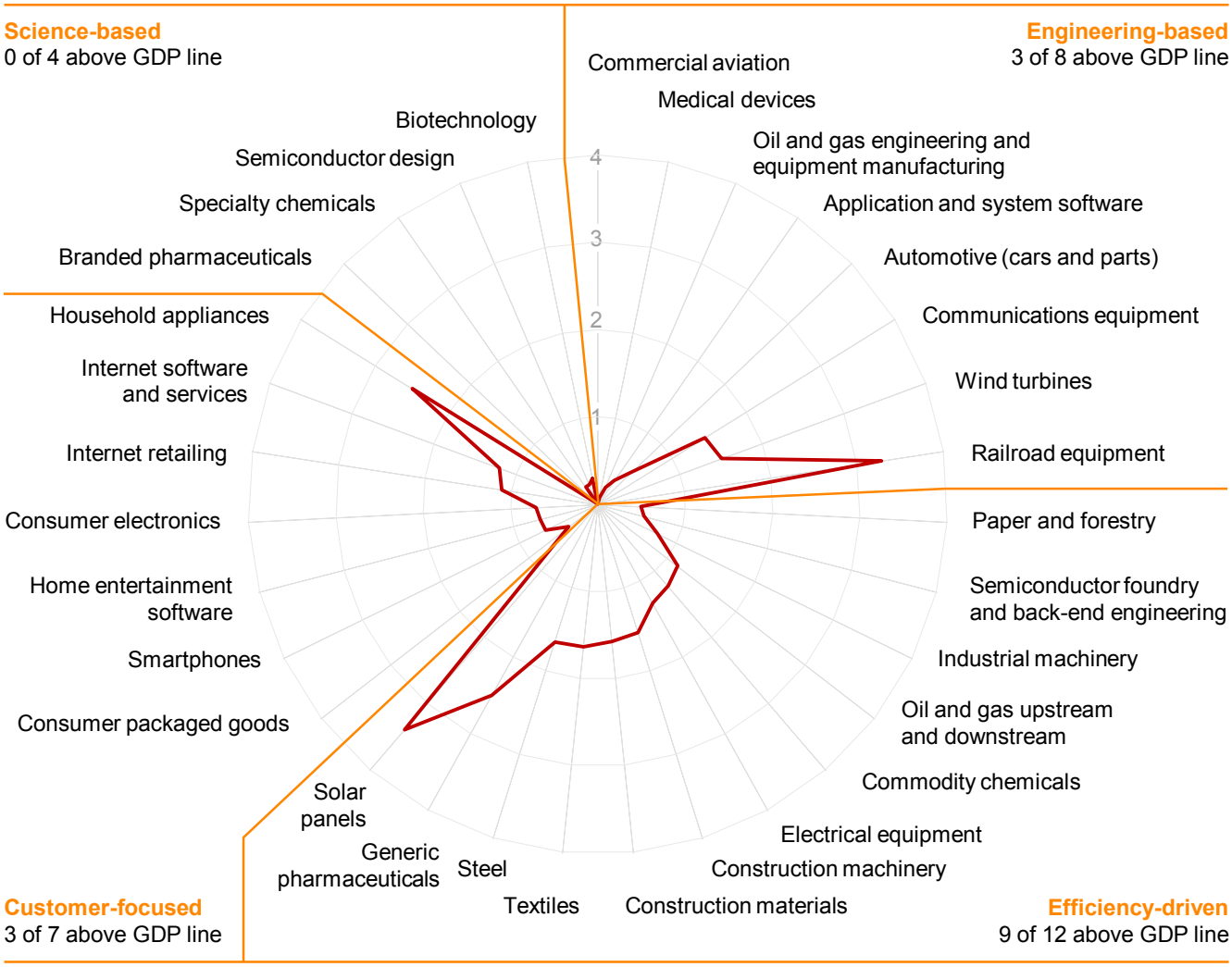
Source: Chris Biggs et al., "What China Reveals About the Future of Shopping," The Boston Consulting Group and Alibaba Group, May 2017 <https://www.bcg.com/publications/2017/retail-globalization-china-reveals-future-shopping.aspx>

In What Sectors Is China Achieving Innovation-Led Growth?

Exhibit E2

China has established strength in efficiency-driven and customer-focused innovation, but lags in science- and engineering-based innovation

Revenue fair share of Chinese companies, 2013[1]
Index: 1 = GDP share



1 This is the ratio of a country's share in the global revenue pool to its share of global GDP.

SOURCE: International Data Corporation; McKinsey Corporate Performance Analysis Tool; company annual reports, IHS Global Insight; iSuppli; McKinsey Global Institute analysis

Source: Jonathan Woetzel et al., *The China Effect on Global Innovation*, McKinsey Global Institute, October 2015. <http://mckinseychina.com/the-china-effect-on-global-innovation/>

Other Industries

Outside the digital marketplace where the innovative capacity of Chinese companies is clear, commercial innovation in China is more uneven, and despite heavy government and private investment has yet to achieve breakthroughs.

With the two pillars of its modern economy—a large and inexpensive labor force and massive infrastructure needs—starting to erode, China's focus on productivity improvement and innovation-led growth is increasing. And while China is playing catch-up in science-based innovation, massive government R&D investment will have an increasing impact.

Semiconductors

The government has placed a high priority on developing a world-class semiconductor industry and reducing China's dependency on foreign suppliers for chips of all types. Among its goals is a 2025 target for China to be producing domestically 70% of the chips consumed by Chinese industry. Overall, $150 billion is being invested in this effort.[53] The government-controlled China Integrated Circuit Industry Investment Fund (known as "the Big Fund"), with $20 billion to deploy, plays a central role and has invested in most of the country's key chip projects in the last three years. This includes co-investment with US companies, such as Intel, in a Chinese chip designer (Spreadtrum) owned by Tsinghua Unigroup, and with Qualcomm in a joint venture with China's largest chip manufacturer SMIC.[54]

In addition to direct government investment and requiring that US semiconductor companies operating in China take on local partners, the acquisition of foreign technology through M&A plays an important supporting role in government strategy. While initially this focused on high-profile, cutting edge acquisitions, it has lately shifted toward smaller, less sensitive targets, sometimes through acquisitions by proxies such as private equity firms.[55] Despite this drive, US companies continue to maintain a large technological lead, innovating faster than their Chinese counterparts and dominating the high end of the market. There is still no Chinese analog to Intel.

Automobiles

Due to quality and other issues, apart from Geely (discussed below), Chinese automakers have so far not succeeded in breaking into global conventional or EV markets.

Commercial Aircraft

Despite heavy government investment, China is still not competitive in global commercial aviation markets. It's multi-decade plan to produce large commercial aircraft to compete with Boeing and Airbus, however, is continuing to make gains. In 2017, the C919 aircraft produced by COMAC (Commercial Aircraft of China Ltd.) had its maiden voyage.[56]

Software

Perhaps due to weak enforcement of intellectual property rights, China has so far failed to develop major software companies of international consequence.

Biopharma

While not yet a world leader, China's capabilities in drug research are growing. Massive population scale is attracting clinical trials and the laboratories of pharmaceutical companies such as Merck and Johnson & Johnson; after the US, China hosts the world's second largest number of clinical trials involving biologic treatments. San Francisco's Fibrogen has created a Chinese subsidiary to develop and market a drug, now approved by China's FDA, to treat anemia related to kidney disease. At the other end of the pipeline, in the last two years Merck, Lilly, Pfizer, and Incyte have signed multimillion dollar deals to sell Chinese-discovered drugs in global markets.

Development in the sector is backed by government programs designed to attract Chinese scientists working overseas, large-scale investment in technology parks for biotech startups, accelerated drug-testing approvals for biotech discoveries, and a massive investment in R&D. In 2016 alone, China dedicated $9.2 billion to a 15-year Precision Medicine Initiative with the goal of mapping 100 million human genomes.[57] Venture capitalists also invested $5.3 billion in China's life sciences sector in 2016, a ten-fold increase from 2011. Lilly established

a corporate venture arm for Asia in 2008, which has subsequently invested nearly all of its $500 million capital in Chinese startups. A partner in the fund observes that "China wasn't even on the radar ten years ago. Now it's impossible to ignore."[58]

While China offers a large market with a rich environment for clinical trials, and is producing quality companies, it is not yet a leader in discovery research. Growing levels of venture investment, primarily by Chinese investors, may be a case of too much money chasing too few quality opportunities. Despite China's growing strength in science and some highly competitive large companies such as Wuxi PharmaTech, its base of life sciences entrepreneurs and startups remains thin, with few doing highly innovative or breakthrough work. This picture is likely to change, however, as an aging population drives new products and therapies, as government investment grows, and as more US university and corporate-trained scientists return home.

Leading Regions Concentrate Innovation Assets

Innovative companies and innovation assets can be found throughout China but are most concentrated in three regions: the Pearl River Delta (centered on Shenzhen and now rebranded as the China "Greater Bay Area"), the Yangtze River Delta (centered on Shanghai and including the cities of Suzhou, Nanjing, Hangzhou, Wuxi and Ningbo), and greater Beijing. Broadly speaking, entrepreneurial activity is most vibrant in Shenzhen and Hangzhou, Shanghai has the largest international presence, and Beijing benefits from its status as the center of government and the strongest research base, with many of the country's best universities and the Chinese Academy of Science.

Shenzhen and the Pearl River Delta

Source: Hong Kong Trade Development Council

Little more than a fishing village in 1979 when it was chosen as China's first Special Economic Zone (SEZ), Shenzhen now has a population of approximately 11.4 million and is China's top exporter, with $233 billion in goods sold in 2016.[59] It is the most dynamic city in the extended economy of the Pearl River Delta, which accounts for 10% of China's GDP and 20% of foreign direct investment.[60] Although the city lacks a major research university, 4.1% of its GDP is invested in R&D (compared to 2% nationally). Eighty-seven percent of research is private sector (versus public sector). For thirteen years it has been China's leading source of international patent applications.[61]

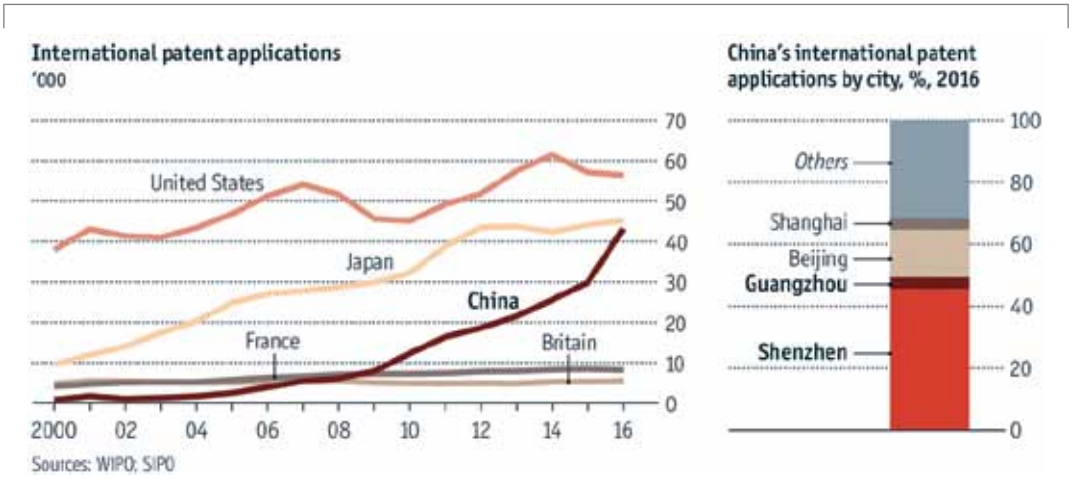
Originally built on labor-intensive industries such as textiles, apparel, and plastics, nearly 70% of gross industrial output is hi-tech, led by information technology strategic and emerging sectors, including networking, new energy, energy efficiency, and biotechnology.[62] Growth in the software sector is also surging. The city is at the heart of China's consumer electronics industry, with thousands of electronic parts manufacturers. This, combined with the manufacturing capacity of its neighbors in Guangdong Province, enables design firms to quickly turn ideas into prototypes.[63]

The pace of development is rapid. The SEZ is home to companies such as drone maker DJI, auto maker BYD, ICT giant Huawei, IT company ZTE, internet giant Tencent, and medical device company Mindray. The Nanshan District alone is headquarters to 125 publicly listed firms with a combined market value of $400 billion; their expenditure on R&D accounts for over 6% of GDP.[64] Smaller companies are also growing, particularly in the field of design. In just two years, for example, manufacturer Qiwo Smartlink Technology has shifted from being a producer of cheap cameras for others to a design house with $100 million in annual sales.[65] Shenzhen is also a highly entrepreneurial city, drawing creative talent from throughout the country to its free-wheeling startup environment.

To compensate for its weakness in basic research, the city is using special funds to directly invest in research institutes, incubators, accelerators, and makerspaces for both entrepreneurs and enterprises. Reflecting this growing scale of activity, since 2016, Apple, Qualcomm, Microsoft, and Intel have established operations centers, research labs, or innovation centers or funds in the city.

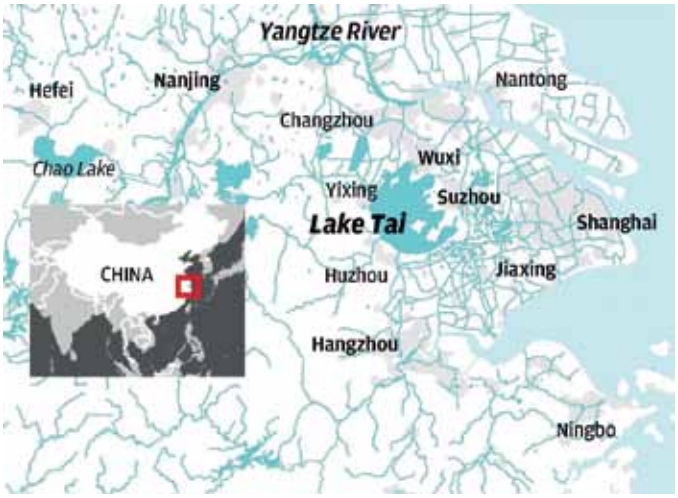
Shenzhen is part of the Pearl River Delta's larger economic system, which is now being rebranded as the China "Greater Bay Area." Composed of neighboring Hong Kong, Macau, the Zhuhai SEZ, and eight other cities in Guangdong Province (including Shenzhen, Guangzhou, and Dongguan) the region aggregates diverse resources on a large scale. The concept of a Chinese Bay Area patterned loosely on the San Francisco Bay Area is included in China's 13th Five Year Plan, the national economic blueprint for the 2016–2020 period, and in 2017 was elevated to the status of a National Strategic Project. Actively promoted by both regional and central government leaders, the Guangdong-Hong Kong-Macau Greater Bay Area comprises 56,000 square kilometers with a population of 66 million and a massive GDP.[66] The plan is to amplify and leverage the region's assets: Hong Kong's legal system, financial expertise, and service industry; Shenzhen's role as a technology center and home to corporate headquarters; and the supply chain and manufacturing capacity of Dongguan, Guangzhou, and the other Pearl River Delta cities.[67] There is much to be done before the vision of an economically integrated region can be realized, with legal and administrative barriers to overcome and barriers to the movement of people to resolve. But economic integration between Hong Kong and Shenzhen is already advanced, with most of the manufacturing that was once done in Hong Kong having moved across the border many years ago, and improvements to regional infrastructure already linking business centers more closely.

Shenzhen Leads China in Patent Generation



Source: "Shenzhen is a Hothouse of Innovation," *The Economist*, April 8, 2017. <https://www.economist.com/news/special-report/21720076-copycats-are-out-innovators-are-shenzhen-hothouse-innovation>

Shanghai and the Yangtze River Delta



Source: *South China Morning Post*

The most cosmopolitan region in China, the Yangtze Delta is home to an international innovation ecosystem centered on the cities of Shanghai, Hangzhou, and Nanjing, as well as Suzhou and Wuxi. It is also home to a disproportionate share of China's 731 million mobile internet users,[68] and a critical market for technology products.

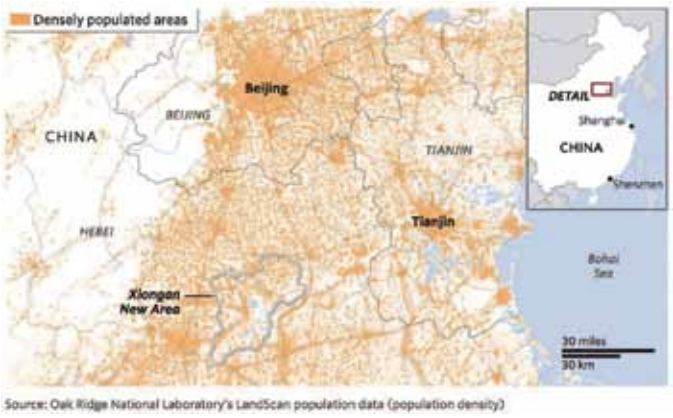
An international trade and financial center, Shanghai also hosts a thriving startup community and research parks that have attracted major global and Chinese companies. Its Yangpu district is a nationally-designated innovation district, hosting companies such as Oracle, IBM, and VMware, and in 2017 hosted China's National Mass Entrepreneurship and Innovation Summit. Fudan University, also in Yangpu, is a leading research university with strong programs in computer engineering and bioscience. Zhangjiang Hi-Tech Park, in Shanghai's Pudong district, aggregates research centers of major Chinese and multinational companies, and incubators and venture capital firms, such as Sequoia and Qiming, are active across the city.

A major entrepreneurial center, Hangzhou is home to the headquarters of companies such as Alibaba and its financing affiliate Ant Financial, internet firm NetEase, and automotive company Geely. Its Zhejiang University is one of China's leading research institutions. Technology activity is centered in two districts, Binjiang and Yuhang. Both have developed massive technology parks with free or heavily discounted office space for both new companies and international talent: Binjiang's Hi-Tech Industry Development Zone covers 12.12 square kilometers,[69] and Yuhang's Future Science and Technology City over 100.[70] Startup growth is particularly strong in Future Science and Technology City, due to proximity to Alibaba's Taobao City and its being a favored location of former Alibaba staff who have launched new ventures since Alibaba's IPO. Another initiative, Dream Town, has been launched as an office park specifically designed to incubate internet companies. Opened in 2015 on a site formerly occupied by granaries, by 2016 it was home to more than 700 startups, most of which receive subsidized rent, cash grants and other support.[71]

Outside the international spotlight, Nanjing generates talent on a large scale. Fifty-three universities and colleges (the third highest concentration in China) enroll the nation's highest concentration of students (more than 800,000), and its second-highest concentration of postgraduates.[72] A quarter of a million students graduate each year in STEM professions. This keeps the labor-related product development costs for startups relatively low. Attracted by the low cost of living and entrepreneurial grant programs, startups cluster in the downtown Gulou district, on Innovation Avenue between Nanjing Engineering University and Nanjing Finance University. Multinational companies such as Ford, Suning, Alibaba, and GenScript have also opened R&D centers.

Suzhou Industrial Park, in Suzhou, was co-developed by the Chinese and Singaporean governments and is one of China's top destinations for multinational technology companies. Wuxi's proximity to Shanghai has attracted startups looking to reduce costs while staying close to investors. The city also hosts a major life sciences sector.

Beijing



Source: *The Wall Street Journal*

Beijing stands out for its leading universities, strength in R&D, and government presence. From 2014 to 2016, the city attracted 54% of China's venture investment, $18.5 billion in 2016 alone.[73] This reflects in part the presence of a large number of venture firms there, including domestic firms as well as foreign firms, such as Sequoia Capital, GGV, Legend, and IDG, that have Beijing offices.

Within Beijing itself, the Zhongguancun district is an active center of entrepreneurship. This stems from the proximity of two of China's elite higher educational institutions, Peking University and Tsinghua University, as well as the Chinese Academy of Sciences. Generous tax incentives aid startups,[74] who can connect to the headquarters of companies like internet giant Baidu and to the research offices of Microsoft and Lenovo. Microsoft has an accelerator which welcomed its ninth cohort of startups in March 2017.[75] Startup activity in the city is also supported by two other large tech centers—Sanlitun and Guomao—which, along with Zhongguancun, offer numerous co-working spaces and networking opportunities.[76] Beijing is home to more unicorns than any other Chinese city; products of its entrepreneurial system include search engine giant Baidu, social media company Weibo, e-commerce company JD.com, smartphone leader Xiaomi, and ride-sharing company Didi Chuxing.

At the macro-level, the central government has announced plans for a new city to be built in Hebei province's Xiongan New Area about 130 kilometers outside Beijing. Designated as an area of national significance similar to Shenzhen and Shanghai's Pudong, and designed to concentrate economic activity and non-core government functions in a sustainable urban environment, Xiongan will be developed under the direct oversight of the Central Committee of the Communist Party and China's State Council. Among other roles, the city—which is predicted to require over $290 billion to build out over 15 years[77]—is also intended to concentrate R&D facilities and serve as a new base for innovation-led technology research, incubation and commercialization. In 2017, the government gave approval for 48 Chinese companies, including Alibaba, Tencent, Baidu, JD.com, and Qihoo 360 to locate there.[78]

Innovative Chinese Companies Are Achieving Global Scale

No Chinese company ranks in the global top twenty for R&D spending or the top ten most innovative global companies ranked by PwC.[79] Clarivate Analytics' *2016 Top Global Innovators Report*, which ranks global companies based on patent volume, application-to-grant success, globalization, and citation influence, lists only one Chinese company—Huawei—in the top 100.[80]

But Chinese firms are increasing their R&D expenditures and generating a growing flow of patents. China has already produced a number of private companies that are dominant in the Chinese market and are starting to expand globally. Many are innovative by any standard. While not all their strategies will succeed, there is no question that these companies have embedded innovation in their corporate cultures, becoming potent competitors. Examples include Huawei, Tencent, Alibaba, DJI, Broad Group, Geely, and Mobike.

Huawei

ICT hardware giant Huawei opened its doors in Shenzhen 30 years ago, as an importer of electronic equipment from Hong Kong. Its founder, Ren Zhengfei, seeing potential in the sector, started building telecom products in the early 1990s. By 2014, Huawei had overtaken Ericsson to become the world's largest vendor of telecommunications equipment. Today, the company supports network operations in 170 countries, with a total of 180,000 employees, 45% of whom are in some manner engaged in R&D.[81] Huawei is listed as a Top Growing Company in Interbrand's Best Global Brands 2017 Rankings and was number ten on MIT Technology Review's 2016 list of the world's 50 Smartest Companies. Revenue stood at $75 billion in 2016.[82] It is currently the top smartphone seller in China and is increasingly competitive with Apple in the premium market (where Apple dominates). While dominating in its home market, Huawei is the third largest smartphone seller worldwide, but that success has not translated to the US, where it has captured less that 4% of the market.[83]

A private company where employees are eligible to hold shares accorded on the basis of performance, its business includes consumer, carrier and enterprise lines. That puts it in competition with sector leaders such as Cisco (ICT), Apple and Samsung (smartphones) and Alcatel, Nokia, and Ericsson (telecom).[84] Ninety percent of its smartphone production is outsourced from Shenzhen to other parts of the China Greater Bay Area and beyond, with 10 percent kept in-house as a way to control standards and keep a hand in mass manufacturing.[85]

Innovation is a critical part of Huawei's business strategy. Huawei supports 15 R&D centers in China and around the world—e.g., in Russia (for applied mathematics), in Sweden (for ICT), in India (for software), and in Silicon Valley (for enterprise solutions)—and invests 10% of its annual revenue in research; it has become one of the world's largest patent holders, with a portfolio of over 62,000 in 2016.[86] The Huawei Innovation Research Program (HIRP), an open collaboration platform, invites proposals for research ideas from around the world, which are assessed at its R&D centers and may subsequently receive support. Overall, the company has sponsored more than 1,200 innovation research projects worldwide, involving researchers at 300 universities and research institutes in close to 30 countries.[87] In 5 cities around the world, Huawei has also established OpenLabs which work with more than 400 partners to facilitate joint innovation and solutions launches in sectors such as smart cities, finance, transportation, energy, manufacturing, and media. Announced in March 2017, its expanded Global OpenLab Program will create OpenLabs in 7 more cities by 2019, and Huawei ultimately plans to increase the total number of OpenLabs to 20.[88]

Anticipating explosive growth in the Internet of Things (IoT), smart devices, and cloud computing, the company is investing heavily in 5G[89] and has committed to AI and an All Cloud strategy in which all of its products and solutions will be cloud-connected to accelerate the digital transformation of telecom carriers and industry verticals. Connected cars are a focus; the company was recognized at the 2017 World Intelligent Vehicle Conference with the Best IoV Award for its cloud-based vehicle platform.[90]

Growing domains include smart homes, smart cities, and smart grid, drawing an expanding number of global clients. The next push will likely be into business consulting and integration services, a move designed to advance Huawei's evolution from being a network equipment supplier to a business solutions provider.[91]

Tencent

With $350 billion market capitalization as of mid-2017, Shenzhen-based internet company Tencent has rapidly grown to become the eighth most valuable brand on the 2017 BrandZ Top 100 list (technology companies Google, Apple, Microsoft, Amazon, and Facebook occupy the first five slots, with AT&T and Visa in the fifth and sixth places), and Tencent is the top-ranked Chinese brand on the list overall.[92]

Its principal services include WeChat (known as Weixin in Chinese) which offers Wallet functions (used for online payments for products and services as diverse as food, movies, utilities, and taxes), and QQ (which offers, among other things, instant messaging, music streaming, and online social games). As of the second quarter of 2017, the tally of Tencent's combined monthly active user accounts for WeChat/Weixin stood at 963 million, and its peak concurrent user accounts number for QQ was 268 million.

Tencent is also the world's largest online gaming company by revenue, based on its domination of the Chinese market. Targets for expansion include animation (Tencent Animation & Comics), Sports (Tencent eSports), and the production of original media content (Tencent Pictures.) An ABC strategy—AI, big data, and cloud—underpins this expansion.

Innovation is taken seriously. Company information about its 30,000 employees reports that the average age is 31, 36% have masters degrees or above, and 50% are engaged in R&D and technical or product testing. The company supports 70 incubators in 25 Chinese cities.[93]

Alibaba

Based in Hangzhou, Alibaba was started in 1999 in the apartment of Jack Ma, a former schoolteacher who saw an opportunity to help small Chinese businesses sell internationally. Since then, it has grown to become one of the world's largest e-commerce companies, providing a market platform for massive numbers of individual and small business sellers. In the fiscal year ending March 31, 2017, 454 million annual active buyers (one in three individuals in China) participated in its China retail marketplaces, and the number of monthly active users accessing them through mobile devices stood at 507 million. Mobile gross merchandise volume (GMV) was $433 billion, or 79% of total GMV,[94] up from 19 percent in 2014.[95] Alibaba was ranked by BrandZ as the 14th most valuable global brand in 2017.[96] Its Taobao website has captured a large share of China's consumer-to-consumer market, beating out US rival eBay, while its Tmall provides a marketplace for branded products.

Filling a void that inhibited the ability of small and medium-sized enterprises (SMEs) to grow, early on Alibaba developed a system where the transaction records of its SME members that might not otherwise be eligible for credit could be shared with banks, creating a de facto credit rating system. In 2010, the company launched an SME loan business, further compensating for the challenge faced by very small companies in securing financing from banks. In 2015, China's first credit agency, Sesame Credit, was created by the Ant Financial Services Group (37.5% owned by Alibaba), which operates the Alipay online payments system.[97]

Listed on the New York Stock Exchange in 2014, Alibaba reached a milestone when its market cap of $472.4 billion first surpassed Amazon's $470 billion market cap on October 10, 2017,[98] placing Alibaba among the top 6 most valuable publicly listed technology companies in the world (along with Apple, Alphabet, Microsoft, Amazon, and Facebook).[99] R&D is an important focus, with $2.6 billion (11% of annual revenue) invested in research in its 2016–17 fiscal year. (By comparison, Alphabet spent $13.9 billion on R&D in 2016, and Amazon spent $16 billion). That number is set to triple, with the announcement in October 2017 of a global research initiative, the Alibaba DAMO (Discovery, Adventure, Momentum and Outlook) Academy, through which the company will invest more than $15 billion over the next three years.[100] The Academy will open seven research labs in China (Beijing and Hangzhou), the United States (San Mateo and Bellevue), Russia (Moscow), Israel (Tel Aviv), and Singapore, focusing on both core and disruptive technology research including data intelligence, IoT, fintech, quantum computing, and human-machine interaction. Within those broad fields, specific areas of focus will include machine learning, network security, visual computing, and natural language processing. Guided by a multinational advisory board drawn from leading universities, researchers will be recruited globally.[101]

Looking ahead, Alibaba's strategy recognizes that e-commerce is evolving rapidly and assumes that the model will change. The vision for the future, in which it is investing, foresees a retail industry driven by the integration of offline, online, logistics, and data across a single value chain.[102]

DJI

Shenzhen-based DJI (Dajiang Innovation Technology Company), the world's leading drone producer, holds 70% of the consumer drone market globally, and 50% in North America. In 2014, it closed a $75 million funding round with Accel Partners, which reportedly valued the company at $8 billion.[103] Its drones have been used for aerial footage ranging from the Golden Globe awards to the mapping of earthquake destruction in Nepal and the monitoring by farmers of cornfields in Iowa.

Founder Frank Wang launched DJI from a dorm room at the Hong Kong University of Science and Technology in 2006, later moving with two classmates to Shenzhen, where he ran the company out of a three-bedroom apartment with what was left of his university scholarship and money from a family friend. Wang's game-changing innovation breakthrough was a gimbal that used onboard technology to adjust a drone-mounted video camera's orientation so the video frame would remain still in flight. A further innovation, in 2016, was the "crash-proof" drone, which uses front-end sensors to detect objects ahead and potentially avoid them.[104]

The Phantom, DJI's first complete drone package that included software, propellers, frame, gimbal and remote control, was released in 2013 as a preassembled quadcopter. It proved a success not just in China but in global markets as well, to the point where today the company now derives equal shares of revenue from Asia, the US, and Europe.[105] Competitively, DJI has been very successful bringing new, advanced products to market, drawing on an R&D workforce of 1,500, local manufacturing in Shenzhen, and sophisticated marketing (including sales through Apple stores). In 2016, DJI hosted a conference (Airworks) in San Francisco to support its planned expansion from the consumer to the commercial drone market, and in 2017 it opened a San Francisco flagship store. DJI's leading US competitor, Berkeley's 3D Robotics, stopped making drones in 2016, shifting its focus to software, while Bay Area action-camera maker GoPro has struggled with its initial Karma drone product.[106]

US drone companies continue to dominate global investment in the sector with a 65% share, followed by China with 5% and approximately $262 million in disclosed funding since 2015. DJI is China's best-funded drone company, having raised $105 million to date from Accel Partners and Sequoia Capital China among others.[107] This is a successful example of how Silicon Valley capital is partnering with the new generation of Chinese entrepreneurs to enable the fast scaling of emerging technologies in both Chinese and global markets.

Broad Group

Broad Group, which began as a manufacturer of industrial air conditioning units, has broken new ground in building construction—an industry where construction techniques have barely advanced in decades. Broad Sustainable Building first reached the spotlight in 2011, when a time-lapse video of its construction of a 30-story building in just 15 days went viral. The core of the 328-foot-tall structure, built using industrial modular techniques, was completed in just 360 hours. Broad's structures are built using fabricated modules that come complete with pre-installed ducts and plumbing for electricity, water, air conditioning and other infrastructure and are assembled like Legos on-site. The product is the world's first standardized skyscraper.[108] A larger 57-story tower—J57 (Mini Sky City)—was finished in 19 days and was selected by *Businessweek* as one of the 40 most exciting innovations of 2015.[109] Founder Zhang Yue observed, "Traditional construction is chaotic. We took construction and moved it into the factory."[110]

The odyssey from air conditioning to construction began with the 7.9 magnitude earthquake that devastated China's Sichuan Province in 2008, causing the collapse of many poorly constructed buildings and the death of 87,000 people. That led to Zhang's fixation on building design and the challenge of developing environmentally friendly buildings that could also withstand an earthquake. His answer was to reconceptualize construction principles: to change the load-bearing structure and reduce building weight, it was necessary to use less concrete in the floors, which in turn made it possible to reduce the amount of structural steel. Having achieved that, 90% or more of what goes into the redesigned structures can be produced and modularized in a factory, with components designed to fit into a container for transport.

Modular and pre-fabricated buildings are increasingly accepted in the West and have been embraced by the sustainable building community. To date, however, most of the modular structures that have been developed in the West are low-rise; Broad is pioneering the modular high-rise. In addition to time, there are other cost and environmental savings. According to the company,

a traditional high-rise produces about 3,000 tons of construction waste, whereas a manufactured one using the company's technique produces only 25. Traditional buildings also require 5,000 tons of onsite water to build, while Broad's buildings use none.[111] Construction costs are said to be 10–30% lower, with up to 96% of the building being recyclable at the end of its service life. Overall, Broad's construction method accelerates the timeline from plan to completion, estimating a 9 month window for a 30-story, 20,000 square meter project: 3 months for design and permitting, 4 months for simultaneous foundation and component construction, and 2 months for transportation and installation.[112]

Geely

Ranked in the Fortune 500 since 2012,[113] Hangzhou-based Geely is China's first privately-owned automobile company. (Until Geely was founded, all automotive companies in China were either state-owned enterprises or foreign joint ventures.) Its founder and CEO Li Shufu, the son of a farmer, launched Geely in 1986, initially manufacturing refrigerators, followed by decoration materials, and then motorcycles.[114] Without a government license to produce cars, he bought a license from a prison facility and then moved its production to a city in Eastern China. The first car off the assembly line in 1998 was the first privately-produced car in China.[115]

Today, Geely spends approximately RMB 10 billion annually on R&D, with 10,000 employees engaged at 10 global R&D centers. It has also developed an open innovation platform that enables people from outside the company to bring ideas and collaborate on research. In 2010, Geely acquired Sweden's Volvo from Ford and has since then leveraged Volvo's research capacity to improve its technology and product lines through a joint R&D center in Gothenburg. That center, which connects to Geely's multiple R&D sites in China, supports both companies and is currently being expanded with a three-year investment of RMB 20 billion. The architecture developed there will be shared between Volvo and Lynk & Co., an new automotive venture with an innovative business model where all sales will be online, based on subscriptions, and cars will have only one price (no showroom haggling). Autonomous vehicles are another priority for the Geely-Volvo collaboration, with pilot programs in China and the US, and deployment targeted for 2021.[116]

Mobike

Bike sharing is big in China, attracting billions of dollars in funding. Mobike (Beijing Mobile Technology) has pioneered a model where shared bikes can park anywhere, not just at fixed stations. The innovation that enables it is the locking and locator technology, which isn't at the docking station but on the bike itself, using technology that leverages mobile payments, GPS- or Bluetooth-tracking, QR code, or other mobile-based authentication. "Dockless" bikes can be found using a smartphone app and, when the ride is done, left anywhere.[117]

A startup only a short while ago, Mobike now runs a fleet of more than 5 million bikes in 130 cities globally (mainly in China), that are used by 100 million customers who collectively take an average of 20 million trips daily. The largest of more than 30 dockless bike startups that have sprung up in China in the last two years, as of early 2017, Mobike had attracted more than $300 million in investment from Temasek, Hillhouse Capital, Sequoia Capital and Tencent. Its next goal is to expand globally, supported by a new $600 million funding round secured in June 2017. With that new investment, its market value is estimated at $3 billion.[118] Mobike recently entered the Singapore, Japan and UK markets and aims to double the number of cities where it operates—including Washington, DC—to 200 by the end of 2017.[119]

First Generation Entrepreneurs

One thing that stands out from this and other analyses is how in the last two decades China has produced home-grown entrepreneurs who have embraced innovation to successfully grow companies with global scale. A breakdown by Matthew le Merle and Alison Davis in *Build Your Fortune in the Fifth Era* shows that 80% of the 25 wealthiest Chinese are first generation (usually technology) entrepreneurs.[120] Like Silicon Valley, and in contrast to many places in the world, China today has no lack of successful entrepreneurial role models.

Ranking of China's Richest People

Rank	Name	Net Worth $B	Core Business
1	Wang Jianlin	$31.6	Dalian Wanda Group
2	Jack Ma	$28.4	Alibaba Group
3	Ma Huateng	$24.2	Tencent Holdings
4	Wang Wei	$16.5	SF Express
5	William Ding	$15.1	Netease
6	Wang Wenyin	$14.7	Amer International Group Co. Ltd.
7	Robin Li	$12.8	Baidu
8	He Xiangjian	$11.5	Midea Group Co. Ltd.
9	Hui Ka Yan	$9.8	Evergrande Real Estate
10	Yao Zhenhua	$8.5	Baonang Group
11	Lei Jun	$8.4	Xiaomi
12	Zhang Zhidong	$8.1	Tencent Holdings
13	Yang Huiyan	$8.0	Contry Garden Holdings
14	Liu Qiangdong	$7.4	JD.com
15	Zong Qinghou	$7.2	Hangzhou Wahaha Group
16	Zhang Shiping	$6.6	China Hongqiao Group
17	Liu Yongxing	$6.6	East Hope Group
18	Xu Shihui	$6.6	Dali Food Groups Co.
19	Li Shufu	$6.3	Volvo
20	Guo Guangchang	$6.2	Fosun International
21	Wei Jianjun	$6.0	Great Wall Motor
22	Xu Chuanhua	$5.8	Transfar Group
23	Pan Zhengmin	$5.7	AAC Technologies Holdings
24	Yan Zhi	$5.6	Zall Group
25	Lu Guanqui	$5.6	Wanxiang Group

Sources: *Forbes*, Fifth Era, LLC

Source: Matthew Le Merle and Alison Davis, *Build Your Fortune in the Fifth Era*, Corte Madera: Cartwright Publishing, 2017

Beyond China: What's Next?

This drive for innovation—"innovation with Chinese Characteristics"—presents competitive challenges for Silicon Valley companies in the Chinese market. For example, at least four Chinese companies—OPPO, Vivo, Huawei and Xiaomi—are selling more smartphones than Apple, although Apple continues to hold the market's high end. Chinese products are almost as sophisticated, and generally cheaper.[121] Leveraging their large domestic base, such up-and-coming Chinese companies are now exploring overseas expansion. Tencent and Alibaba in particular are pushing into global markets, aiming to reach beyond the highly-competitive and nearly-saturated domestic market, to a global base that both grows revenues and reduces the possibility that technologies developed in China's walled-off hothouse environment might be disconnected from global trends.

Those markets include the US, where Alibaba, for example, has little market penetration and can't compete with Amazon (yet) but is aiming instead to help US small businesses sell in China through its Taobao platform. The initiative was launched with a two-day conference in Detroit in June 2017, aimed at connecting US small businesses with Chinese merchants that maintain digital storefronts.[122] While opening a potentially large market for small US businesses, the strategy faces several challenges, including the widespread presence of counterfeits on Taobao (which primarily serves small sellers), and concerns among US sellers that if they list on Taobao, knockoff products will quickly appear at a lower price and be difficult to remove. Alibaba's other shopping site, Tmall, is used by brands directly and is more easily policed.

In emerging markets, Alibaba's primary focus is on Southeast Asia. Building on partnerships in Asia, Europe and the US, Alibaba's affiliate Ant Financial Services Group is targeting the growing numbers of Chinese tourists who are traveling abroad and who already use Ant's Alipay mobile payments platform at home. This could set up Ant to challenge US companies Visa and Mastercard, but head-to-head competition is unlikely since Alipay doesn't link to non-China bank accounts. Some US companies, on the other hand, stand to gain. For example, Alibaba is developing a partnership with Marriott International to enable Chinese travelers to use Alibaba's travel website to book rooms at hotels that Marriott operates worldwide and to use the Alipay smartphone payment system at Marriott properties overseas. The arrangement allows Alibaba to follow Chinese travelers when they go abroad and Marriott to benefit from Alibaba's customer data and understanding of Chinese consumer tastes, to drive bookings to its hotels.[123]

Tencent, whose share of China's online payments market is growing, is also following Chinese tourists and businesses overseas, making its WeChat Pay service available to Chinese customers when they travel outside China.[124] Like Alibaba, Tencent is initially targeting this expansion to other Asian countries, due to cultural similarity and their high concentrations of Chinese visitors. Tencent is also establishing its JOOX music streaming service across the Asia-Pacific region, utilizing local teams to curate playlists that cater to regional tastes in each Asian market.[125]

Gaming is another market. Tencent has quietly become the world's largest game publisher by revenue, surpassing US companies like Electronic Arts and Activision, largely on the back of its domination of the Chinese market. Global expansion is a priority, but the company still has a limited profile outside China. Its global drive has focused principally on acquisitions and alliances with overseas partners rather than export of its domestically produced products. Major acquisitions include Finland's Supercell (maker of Clash of Clans) for $8.6 billion and Los Angeles-based Riot Games (maker of League of Legends) for an undisclosed amount.[126]

Internet companies such as Tencent, Baidu and Alibaba are also positioning themselves for global expansion by investing in digital technologies that can be deployed in electric vehicles. Tencent, for example, recently invested in the Chinese startup Future Mobility, which is targeting the US and European markets.[127] It has also invested in Tesla.[128] Other EV companies looking to expand internationally include China-backed startup Lucid Motors, which aims to become a luxury-brand competitor to Tesla. Based in Menlo Park with approximately 300 employees,[129] including a number of Tesla alumni, it plans to start building luxury cars at a factory in Arizona in 2018; though not autonomous, its first car, the Lucid Air, will incorporate self-driving technology.

It may require a major leap before China's internet companies can become truly global or compete outside of China with US players like Google or Facebook. In some respects, the challenge is cultural, while in others it is a product of how these companies have grown in China's largely protected environment. China's policy of walling off the internet from global competition has helped grow companies with enormous scale domestically but has also created a bifurcated global market in which China stands apart from everywhere else. This closed environment may have the effect of isolating China from global trends and business models, limiting the carryover of Chinese experience to Western and other markets. For example, Tencent's WeChat is extensively used for payments in China but has only a small uptake in the US, where it is largely limited to chat and photo sharing, and where Facebook apps WhatsApp and Messenger dominate. Its 2016 effort to bring its WeFire game to US markets through Glu Mobile, a San Francisco company in which it has a minority stake, failed in part because unlike in China where most players play on mobile devices, Western gamers normally play shooting games on personal computers or consoles, rather than smartphones. WeFire's US version, Rival Fire, ended up low in the rankings of top action games on iPhones and iPads in the US.[130]

Chinese startups expanding into global markets face a similar challenge, as products designed and developed for the Chinese market don't necessarily translate outside of China.

Startups and Venture Capital

Beyond its business giants, China is also home to a robust and growing startup scene. Dave Jones, President of SPD Silicon Valley Bank and SVB Asia observes, "China is a huge market with thousands of very good entrepreneurs that are creating many of the most interesting innovation companies on an international level. The existing funding from private and public sources will continue to propel the Chinese innovation market forward and entrench China as Silicon Valley's primary global competition for innovation."

The central government and provincial and local governments are increasing their support for startups, with Chinese Premier Li Keqiang visiting incubators in Beijing and Shenzhen to promote Chinese startups as an engine of growth. Reflecting this, the number of incubators, accelerators, and co-working spaces in China is growing rapidly.

Governments across China are also offering subsidies and tax breaks to support the development of "innovation hubs." Beijing provides annual subsidies to startups and incubators; Guiyang, in Western China, offers free rent to startups that move to its high-tech zone; Tianjin, close to Beijing, aims to build 100 innovation hubs; and Suzhou plans to build over 300 incubator-style facilities by 2020. It remains an open question whether there are enough qualified startups to fill these spaces, or whether the government's enthusiasm will be effective in stimulating innovative activity. Kai-fu Lee, a former Google and Microsoft executive who in 2009 founded one of China's first incubators, China's Innovation Works, believes that only 5% of incubators in China have the capacity to provide funding and high-quality services to support startup growth.[131] Many of the rest are real estate plays.

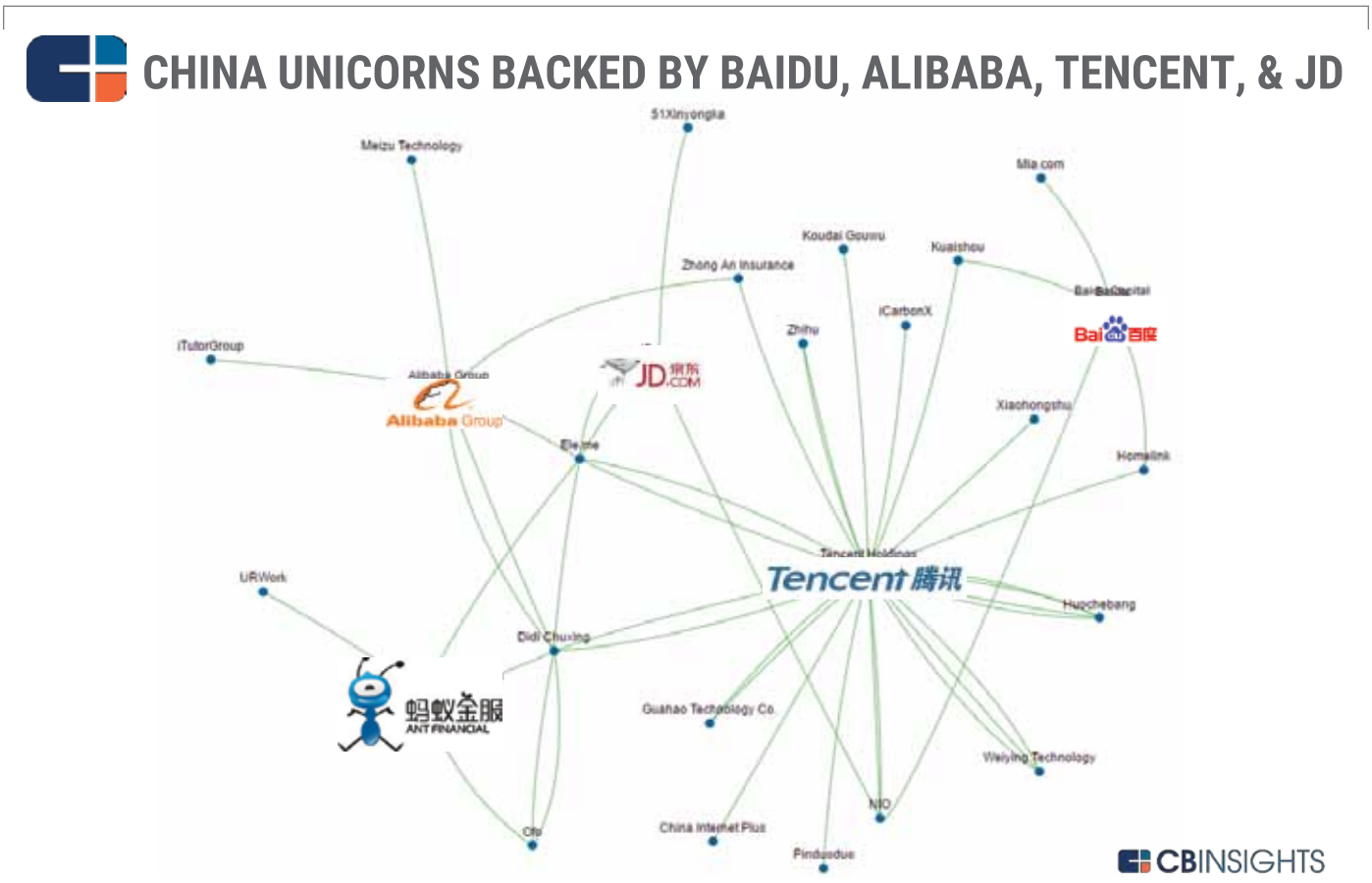
Nevertheless, as in other areas of innovation policy, China's government agencies are devoting major resources to the effort, some of which will bear fruit.

More interesting, perhaps, is the growing focus of private companies on startups, through sponsored hackathons[132] and corporate incubators and accelerators designed to accelerate innovation in areas supportive of their business models. This drive is paying off in the form of billion dollar startups. Chinese companies top the list of Asia's unicorns (companies with valuations of $1 billion or more), led by ride-sharing company Didi Chuxing ($50 billion), Xiaomi ($46 billion), China Internet Plus ($20 billion), Lu.com ($18.5 billion), Bytedance ($11 billion), and DJI ($10 billion).[133] In 2016, China claimed 37 unicorns, compared to India, which was number two with 8.[134] Among investors, Tencent and Sequoia Capital China top the list in 2017, with 19 and 13 unicorns respectively, followed by Hong Kong-based DST Global and Qiming Venture Partners, each with 8.[135]

Internet companies received more than half of China's venture deal flow in 2017 Q1, followed by telecom and mobile companies. Digital health and fintech also attract major funding. Of China's 46 unicorns in 2017, 21 (46%) are backed by China's largest internet companies—Alibaba, Baidu, JD.com, and Tencent—or their affiliates such as Alibaba's Ant Financial. Alibaba and Tencent are also increasing their investment in startups in neighboring Asian countries, particularly India and Korea.[136] China's government is an active investor, with $231 billion in government-backed venture funding deployed.[137]

Whether from public or private sources, the scale and sophistication of venture and private equity funding has grown strongly in the last two years. By one report, venture and private equity funding grew 49% in 2016,

Tencent Has Backed the Highest Number of Chinese Unicorns



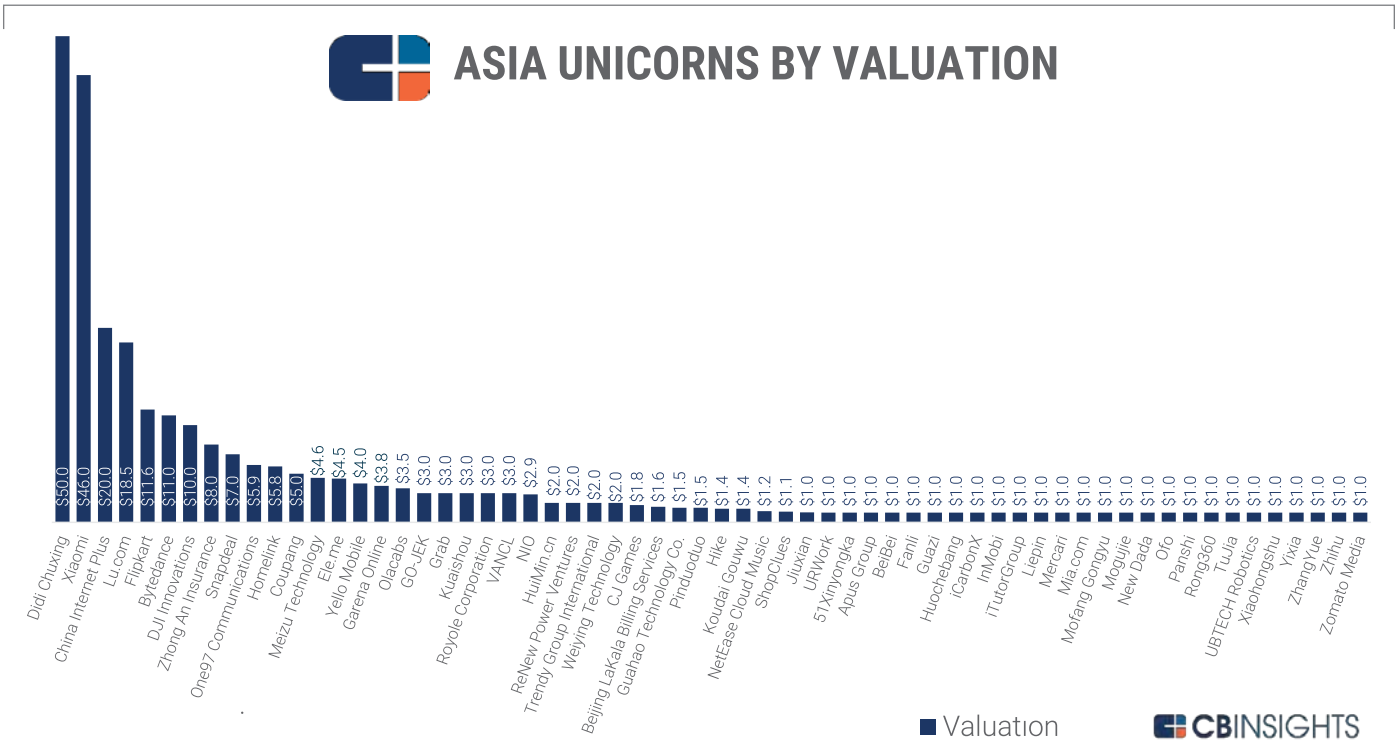
Source: "CB insights asia-tech-investment-report—SlideShare," *CB Insights*, May 23, 2017, p. 20. <https://www.slideshare.net/galengrowthasia/cb-insights-asiatechinvestmentreport>

to $72.5 billion, while funding raised in RMB increased 177% to $54.9 billion (equivalent).[138] As a reflection of this growth, Chinese companies are poised to go public in large numbers. Sixty mainland companies (not all in tech) launched IPOs outside of mainland China's Shanghai and Shenzhen exchanges in 2016, and Nasdaq estimates that 60 more—more than half in tech—could go public in the US in the next two years, with a combined value of $200 billion.[139]

China is one of the few places in the world that has succeeded in developing an integrated innovation system—with university research, engineers, venture capital, accelerators, and a large consumer base—comparable to Silicon Valley's. But while it is highly energized and is growing rapidly, China's startup and entrepreneurial scene remains underdeveloped in comparison. Having a large number of accelerators and working spaces doesn't always correlate with innovation. Also, Chinese investors often look to monetize their investment as quickly as possible, pushing startups for near-term revenue as opposed to transformational leaps. (Silicon Valley, by contrast, excels at generating and supporting entrepreneurs who are passionate, are technically driven, and set ambitious goals.) This reinforces an orientation toward quick money—something not unknown in Silicon Valley but more pronounced in China. While exceptional entrepreneurs exist, even among startups the business culture can be collective and top-down, which fails to promote radical or disruptive thinking.

While generating high-quality science and increasing their support for startups, universities in China are also behind the curve. In Reuters' annual ranking of the world's 100 most innovative universities—those doing the most to advance science, invent new technologies, and power new markets and industries—only three Chinese universities make the list: Tsinghua University (#51), Peking University (#60), and Zhejiang University (#100).[140] A 2016–2017 report by Pitchbook on universities producing successful VC-backed entrepreneurs (measured by investment capital raised by startups) finds no Chinese undergraduate university in the top 50 global institutions, and no Chinese MBA program in the top 20. Only one Chinese university, Zhejiang, is included in the rankings—at number nine in the production of unicorns.[141]

62 Asia Unicorns Are Valued at $283.5 Billion in Aggregate



Source: "CB insights asia-tech-investment-report—SlideShare," *CB Insights*, May 23, 2017, p. 20. <https://www.slideshare.net/galengrowthasia/cb-insights-asiatechinvestmentreport>

Government Policies

China is not a normal market economy as it would be defined in the United States, Europe, or Japan. It is, instead, an economy within which market mechanisms operate, but where government policy guides its direction, influencing the decisions of both business and state-owned entities through layered incentives and disincentives. While it is not unusual for governments around the world to play an active role in planning or guiding their nations' economies, China is different because of the extraordinary depth and extent of its industrial policies. It is also different due to the pervasive influence of the Communist Party, which maintains a political monopoly whose reach extends not just to all levels of government, but also to State Owned Enterprises (SOEs), state-invested companies (where the government has directly provided resources), and private enterprises (where all but the smallest have embedded Party Secretaries).

Even for private companies, it is important to demonstrate loyalty to the government and align with national government policies. Engagement is rewarded, while deviation or too much independence has consequences, sometimes severe. In this respect, working with a Chinese company may be operationally similar to working with a company from the UK, Germany, Japan, or India; the distinction, however, is that in China, government entities, SOEs, and even private companies are ultimately connected to national government strategies in which they are expected to play a part. It is important, then, to understand what those national strategies are.

Core Plans

China has several core policies that relate to innovation and ultimately to the role and competitiveness of US technology companies doing business there. While many policies are associated with national security, commercial and competitive objectives are also prominent. The four most important government plans are the 13th Five Year Plan, Made in China 2025, the National Medium- and Long-Term Program for the Development of Science and Technology (2006–2020), and the National Innovation-Driven Development Strategy Outline. These plans overlap and support each other, setting an overarching policy direction.

The 13th Five Year Plan

Guiding government strategy for the 2016–2020 period, the 13th Five Year Plan prioritizes indigenous innovation, the achievement of technological self-sufficiency, the control of standards, and an expanded government role in the market. The industries it prioritizes overlap with those targeted in Made in China 2025.

Made in China 2025[142]

Made in China 2025 (MIC 2025) is an industrial policy designed to advance China's global leadership in manufacturing by promoting indigenous innovation, domestic brands, domestic standards, domestic production, and the control of data. Its scope reasserts the government's role in central economic planning in ways that favor domestic companies over foreign ones in strategically selected sectors. One of its many objectives is the development of national corporate champions that will one day become global market leaders. It does this in part by setting global sales and market share targets for Chinese products, backed by directed government resources. Those resources can be used to fund foreign technology acquisitions, among other purposes.

MIC 2025 targets ten priority sectors: next-generation information technology; high-end numerical control machinery and robotics; aerospace and aviation equipment; maritime engineering equipment; advanced rail equipment; new energy vehicles; electrical equipment; new materials; bio-medicine and high-performance medical devices; and agricultural machinery and equipment. Several industries—including large aircraft, aircraft engines, new energy vehicles, smart grids, and medical devices—are identified as targets for increased research and development. Increased indigenous IP in advanced equipment is also targeted.

MIC 2025's overarching objectives include localizing and indigenizing technology and R&D; substituting local technology for foreign technology through indigenous innovation or foreign acquisitions; and capturing domestic and global market share in the targeted sectors.

Supporting policies encourage banks to provide financial support for Chinese brands and strategic industries. Large state-guided funds are also directing resources into R&D and the development of indigenous

technology in the targeted sectors. By one report, 800 such funds with a total value of RMB 2.2 trillion have been established for this purpose. For example, the Integrated Circuit Fund (IC Fund), created in 2014 to support the development a domestic semiconductor ecosystem, is being expanded to support MIC 2025's domestic market share targets. Similarly, China's government is heavily subsidizing electric battery manufacturers—as opposed to consumers, the strategy typically chosen to support renewable energy in the West—to advance targeted technologies.

National Medium- and Long-Term Program for the Development of Science and Technology (2006–2020)

Known as the MLP, the program targets accelerated development and Chinese leadership or dominance in 400 strategic technologies across all advanced industries. It calls for China to become an innovation-oriented society by 2020 and a world leader in science and technology by 2050, and it commits China to developing indigenous innovation that will enable it to advance to leadership in science-based industries. Under the plan, China is on a path to invest 2.5% of GDP in R&D by 2020 (up from 1.34% in 2005), raise the contributions of technology-led overall economic growth advances to more than 60%, and limit its dependence on foreign technology to no more than 30%. The MLP also calls for China to become one of the top five countries in the world in invention patents and most-cited scientific papers. The plan identifies priority fields and 13 government-led and funded mega-projects in engineering and science, with the greatest concentration in the physical sciences.[143]

National Innovation-Driven Development Strategy Outline

Produced by the Central Committee of the Communist Party and the State Council in 2016, the Outline lays out China's science and technology plans and policies, promoting objectives similar to those of MIC 2025.

Supporting Policies and Standards

A number of other policies support and amplify the four core plans.

National Security Law

China's 2015 National Security Law calls for "secure and controllable" information and data systems as applied to the internet and core information technology, critical infrastructure, and other major areas. "Secure and controllable" implicitly refers to systems of Chinese origin. When implemented through regulations, the law effectively ensures that foreign companies cannot qualify without surrendering their source code or encryption algorithms.

Foreign companies that in the normal course of business would be transferring data outside China are now required to store data generated in China on servers located within the country. China is not the only country seeking to restrict the cross-border movement of data and, like other governments, is seeking to manage cybersecurity risks. Issues surrounding the government's desire to create national champions and to control access to information for political and other reasons, however, make China a special case.[144] Foreign investors are also subject to potentially onerous national security reviews, based on an expansive definition of "national security" that extends to many aspects of the domestic economy as well as social policy.

National Cybersecurity Strategy

China's National Cybersecurity Strategy, like its 2016 Cybersecurity Law, calls for the expanded use of "secure and controllable" products in a continuing push toward internet sovereignty and reduced reliance on imported ICT products and services. "Secure and controllable" again is not defined, but essentially creates a preference for Chinese companies and sets a course toward the increased use of domestic IP and encryption. In the banking sector, for example, in 2014 China's Banking Regulatory Commission (CBRC) produced a draft measure that called for 75% of ICT products used in the banking system to be "secure and controllable" by

2019, and imposed criteria that effectively shut foreign ICT providers out of the sector. China has subsequently assured the US and other governments that the measure was not intended to restrict market access, but concerns remain, and China's "secure and controllable" ICT policy continues to contain discriminatory indigenous innovation preferences.[145]

Under President Xi Jinping, the role and influence of the Cyberspace Administration of China (CAC) has been strengthened, with the goal of centralizing party and government control over social media and internet content, ICT innovation, and cybersecurity. Implementation of the Cybersecurity Law and related regulations by the CAC is a priority.[146]

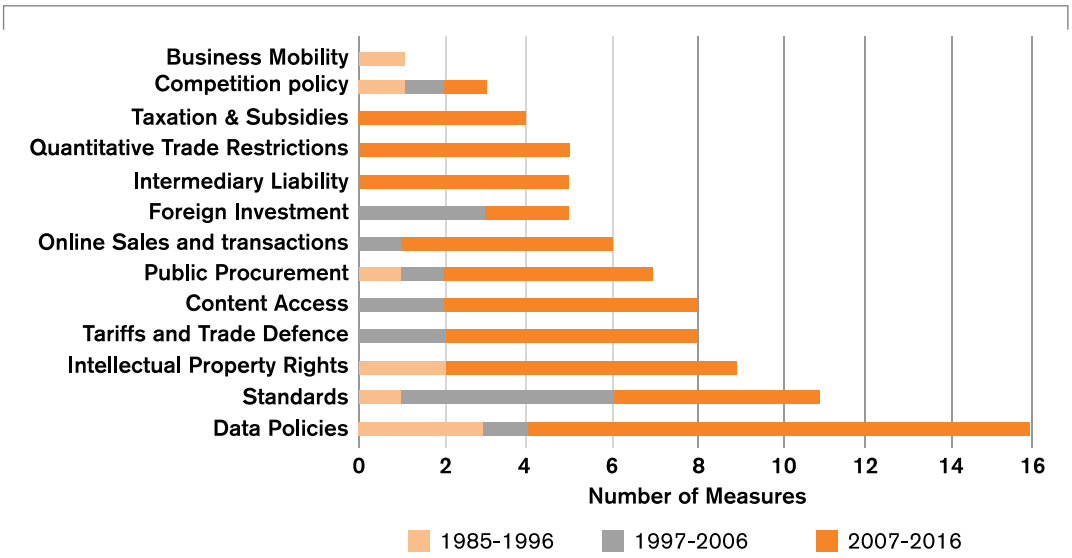
Social Credit System

China is implementing an ambitious AI-enabled platform that uses big data to monitor, rate, and regulate the behavior of all market participants. Termed the Social Credit System, at one level it reflects China's rapid digitization. More than a credit rating system, it is designed primarily to monitor the citizen behavior of individuals, but it is also expected to have significant impact on companies and other institutions, which can be seen as legal persons in China. In addition to market behavior, non-market criteria such as social, environmental, and political activity will be factored into a person's or entity's rating, which can then impact access to loans but, for businesses, may also impact taxes, access to publicly funded projects, and the ability to invest or issue bonds. It remains to be seen what the impact on foreign businesses, if any, will be, but in addition to possible systemic benefits such as increased efficiency and transparency, the Social Credit System will also increase the incentives for both domestic and foreign companies to make business decisions that conform to the government's strategic priorities and industrial and technology policy targets.[147]

Standards

China is increasingly pursuing its own technology standards (for example, in cloud computing, industrial software, big data, and smart manufacturing) that may diverge from global ones, further advancing indigenous innovation goals.

Evolution of Barriers Inhibiting Participation in China's Digital Economy: Number of Discriminatory Measures Currently in Force in China, 1985–2016



Source: Digital Trade Estimates Database, ECIPE, May 2017

Source: Marina F. Ferricane and Hosuk Lee-Makiyama, *China's Technology Protectionism and Its Non-Negotiable Rationales*, European Centre for International Political Economy (ECIPE), 2017. <http://ecipe.org//app/uploads/2017/06/DTE_China_TWP_REVIEWED.pdf>

Other Issues

Intellectual property protection remains a challenge. Despite IP being protected under Chinese law, growing awareness in business and government of its importance, and some highly visible prosecutions, enforcement is weak, and levels of IP infringement remain high.[148] In some cases, Chinese companies will actively recruit managers and experts from leading US and European companies in order to poach technology. Uncertainty regarding IP protection can discourage smaller US companies (which lack the resources to defend their interests) from entering the market and often causes larger companies to restrict the level of technology they bring to China, in order to ensure that their highest value IP isn't lost.

These policies and concerns have implications both inside and outside China.

Internally, they can tilt the competitive playing field in ways that particularly disadvantage foreign technology companies. According to the OECD, China has the most restrictive investment environment among the G-20 countries[149] This is particularly the case for priority industries. The ability of many Chinese technology companies to grow inside a protected market enables them to build scale and accumulate resources in ways that would be difficult in a less restricted market environment.

The most obvious restrictions impact the internet, a particular concern for Silicon Valley companies. Because of censorship (the "Great Firewall") and, in Google's case, data protection concerns, Google and Facebook are unable to operate in China. Other Silicon Valley companies that do operate face growing restrictions. As part of a crackdown on online publishing by foreign companies, for example, in 2016 regulators blocked Apple's iBook and iMovie services. In January 2017, the government announced that only government-approved Virtual Private Networks (VPNs)—which create encrypted links between computers and can be used to see sites blocked by the government's web filters—would be allowed, prompting concern about privacy and the possible loss of trade secrets; in July, state-owned China Telecom notified its corporate customers that in the future they will be permitted to use VPNs only to connect to their headquarters abroad and not to other sites, further limiting access in China to news and cloud-based business services.[150]

Foreign companies are often required to form joint ventures with Chinese companies if they want to serve the market, potentially forcing the transfer or sharing of proprietary technology. This applies, for example, to New Energy Vehicles (a Made in China 2025 priority sector), where technology transfer requirements ensure that virtually all related IP is disclosed and transferred. Technology companies, particularly those affected by the Cybersecurity Law, also find that barriers to doing business in China fall off or disappear after they agree to take on Chinese partners.

Competition and Expansion

Government plans and intense competition produce challenges for both Chinese and US technology companies.

Not Everything Works

While recognizing China's advances, it would be a mistake to think of China as a remorseless juggernaut sweeping everything in its path. Having a plan doesn't guarantee success, and not everything works.

The unevenness in China's economy can be seen in its state-owned enterprises, which are in most cases inefficient, burdened with excess capacity, and surviving on civil works projects and loans from government banks. Few can be considered innovative. Outside the major urban centers of the Pearl River Delta, the Yangtze Delta, Beijing, and major cities such as Chengdu and Wuhan, the economy is less advanced and disparities are large. Disposable income in the countryside is only about a third of that in the major cities.

China's economy has a legacy of investment in manufacturing and heavy industry and what many leaders believe is an over-reliance on foreign technology, and government plans seek to transform it into one that is more service-based, innovation-led, and ultimately more autarkic. While these goals drive government policy, state-owned enterprises continue to absorb a disproportionate share of government resources and typically receive loans from state banks at substantially lower rates than smaller, more entrepreneurial (and more risky) private companies.

Private companies, which now account for three-fifths of the economy, can be impacted in different ways by government policies, which can be a two-edged sword. Even the largest must be careful not to run afoul of the government as China's current leaders push for more centralized political control of the economy and society. From this perspective, it is debatable whether any major company in China is truly "private" as the term is thought of in the West. A growing number of corporate leaders have been prosecuted by the government after falling out of favor and, most recently, China's internet giants have been reined in when their reach has been seen as potentially undermining the Party's control. This was evident when in the spring of 2017 China's internet regulator ordered Tencent's QQ.com to shut down its "Think Big" feature, which ran commentaries by historians, economists, political scientists, and other intellectuals. Other leading internet portals were told to close sections covering the military, international affairs, and Taiwan, and video-streaming sites used heavily by younger Chinese had US, UK, Japanese, and South Korean film and TV programming removed. In addition to its impact on foreign content providers, the crackdown may dampen investment in Chinese online entertainment startups.[151] Restrictions of this kind can also impact innovation if scientists and business leaders can't exchange information freely with their global counterparts and partners.

The government's influence in private companies is about to become more direct with a new plan to take 1% stakes in both large and small technology and social media companies. Targets include Tencent, Weibo, and Youku Tudou, a video platform owned by Alibaba. This follows the pattern set by early stakes taken in two internet media startups through "special management shares" that will enable the appointment of government officials to serve on corporate boards. Financial investment in startups will come primarily through SOEs, while investment in larger companies will be through government backed funds. Agreement to the investment may in some cases be necessary to secure government licenses or favors.[152] While providing cash, the insertion of government representatives into corporate management and operational decisions is another factor that may over time restrict the ability of China's otherwise dynamic private sector to innovate.

Apart from government and policy concerns, private business plays can also go off the rails. For example, Huawei has been largely shut out of the US telecom market by security concerns that surfaced in 2012 when a Congressional report recommended that US carriers avoid using its networking gear due to security concerns. This has discouraged contracts with major carriers. As an alternative, Huawei has worked since then to develop local relationships with smaller carriers. It is also trying to enter the US smartphone market. The US is the missing piece in a global expansion that already has Huawei strongly positioned in Europe, the Middle East, Asia, and Latin America.[153]

In October 2016, Chinese tech conglomerate LeEco announced a suite of products for the American market, including $249–$399 smartphones, HDR and ultra high-definition TVs, virtual reality goggles, electric bikes, and a self-driving electric car. The company also announced that it would pay $2 billion for TV maker Vizio (becoming the second largest seller of TVs in the US) and unveiled plans for a North America headquarters with 12,000 employees on 49 acres in Santa Clara purchased from Yahoo.[154] Plans for a massive electric car plant in Vallejo were also announced by Faraday Future, a potential Tesla rival owned by LeEco's founder Jia Yueting.

Less than a year later, in March 2017, plans for Faraday Future's Vallejo plant were scrapped, and plans for another production facility in Las Vegas were sharply scaled back.[155] At this writing, the Gardena-based company is still operating and says it will lease a factory near Fresno to produce 10,000 cars a year, but with the assets of its principal investor frozen by a Chinese court for failure to pay the interest on loans taken out to support LeEco's expansion, the future is uncertain.[156] In April 2017, LeEco's deal with Vizio was also scrapped, and in May the company announced that it would sharply reduce its US R&D and workforce after failing to attract customers or raise funds for the expansion. LeEco's US ambitions faltered for several reasons: over-diversification, overextension, and the belief—quickly proven wrong—that a company with a household name in China could easily compete and succeed in the US market.

Even as Chinese companies grow their global presence, the competitive landscape for overseas technology inside China is becoming increasingly difficult, due not only to the policy environment but also to the strength of Chinese competitors.

This is clearly the case for internet-based companies—where, for example, eBay's effort to establish a foothold in the China market failed when confronted with competition from Alibaba—but extends to other sectors as well. Ride sharing is one example. Chinese ridesharing company Didi Chuxing, which considers itself a technology company, delivers 20 million rides a day in 400 cities across China, using a sophisticated algorithm that predicts demand 15 minutes ahead for urban districts.[157] Until recently, Uber competed with Didi Chuxing but, after losing billions in a race for market share, withdrew from the market in 2016, selling its China operations to Didi.[158]

Didi, which also absorbed its other former rival Kuaidi, is now moving into other Asian markets to compete with Uber. In 2015, it invested $350 million in Grab, Uber's principal rival in Singapore, Malaysia, Thailand, Indonesia, and Vietnam, and co-invested another $600 million in Grab with Softbank in 2016. As part of the same strategy of funding Uber rivals, Didi also invested $30 million in India's Ola in 2016. Who ultimately gains or loses and how that happens is a more complex question. While Uber is being directly challenged in Southeast Asia, investors in Didi such as GGV Capital, GSR Ventures, Matrix Partners China, and consumer facing corporate investors, such as Tencent, Alibaba, Baidu, Apple, and Uber itself (which since merging it's China operations is also an investor in Didi), stand to gain.[159]

This highlights China's growing presence in foreign markets and particularly in developing economies. China's presence and economic influence is growing in South America, Africa, and especially Southeast Asia, providing alternative technology products and resources.

A Complicated Landscape

Even the strongest Silicon Valley companies are confronted with major policy and competitive challenges when doing business in China. Some are finding success while others have left the market, and some have been denied access.

Apple, which manufactures most of its iPhones in China, now counts China as its third largest global market (having recently slipped from second place), but its services—particularly its App Store—are a key market in China, having logged double-digit revenue growth there in the early part of 2017.[160] In addition to a strong challenge from Chinese competitors, Apple has been under pressure from Chinese authorities to store its data locally and share proprietary source code with the government. Since 2014, some of its Chinese data has been stored at a facility operated by China Telecom, though the data is encrypted and not accessible to the government or China Telecom. In 2017, it announced that to comply with the Cybersecurity Law it would store all cloud data for its Chinese customers at a data

center operated by Guizhou-Cloud Big Data Industry Company, a company owned by the Guizhou provincial government. In the future, Apple's cloud storage service will bear the name of both companies—the first time iCloud has been co-branded.[161]

Apple's online book and movie service was shut down by the government in 2016, after it refused to share its source code. In December 2016, at the government's request, it removed *The New York Times*' Chinese language news apps from its Chinese app store, and in August 2017, to comply with the government crackdown on VPNs, Apple removed from its app store in China software that allowed customers to circumvent the country's web filters.[162]

On a different front, Apple invested $1 billion in 2016 in Didi Chuxing, making it the ride-sharing company's single largest investor. The investment is expected to position Apple for growth in China's future autonomous and connected vehicle market.[163]

Google withdrew from China's market in 2010 due to censorship and hacking concerns but is building a tech team there to tap into the country's growing capacity in AI. With hundreds of millions of people on the internet and massive data being generated from mobile payments and social media, China is seen as offering important advantages. In September 2017, four AI-related jobs and nearly sixty positions overall in Beijing and Shanghai were advertised on Google's website. Focus areas include natural language processing, data compression, and machine learning.[164]

Like Google, Instagram, Twitter and Facebook are also blocked in China. In the summer of 2017, Facebook's last major product available in China, the WhatsApp messaging service, was disrupted as part of an ongoing internet crackdown. WhatsApp isn't widely used in China, where WeChat dominates, but it is used by Chinese to communicate outside the country.[165]

In 2016, HP sold 51% of its networking business in China to Tsinghua Unigroup, an affiliate of Tsinghua University, making the networking unit a Chinese company now called New H3C Group. Microsoft, Qualcomm and Cisco have formed joint ventures in order to address Chinese security requirements.[166]

For Tesla, China is the second largest global market after the US, with 11,000 cars worth $1 billion sold in 2016.[167] That's with the 25% levy on imported cars. Previous to the October 2017 announcement of Tesla's agreement with the government that will allow it to manufacture electric vehicles in Shanghai without a Chinese partner, Tesla had been reluctant to manufacture in China, due to concerns over intellectual property protection.

Netflix reached an agreement in 2017 to provide television programming to iQiyi.com, Baidu's streaming video service, gaining access to the only major global market where its service had been unavailable. [168]

Where Uber and eBay tried and failed to enter China's market and Facebook and Google are frozen out, Airbnb is making headway. It has localized its platform through agreements with Alibaba and Tencent that enable Chinese travelers to sign up via Weibo and WeChat, and in 2016 it established Airbnb China to handle operations.[169] Since then, China has risen to become one of the company's top ten global markets, having doubled the company's listings to 80,000 in 2016. Airbnb faces two well-funded competitors, but the market is considered large enough that all can grow, and the company's ability to support Chinese traveling outside of China is an advantage.[170]

Bridging Opportunity: Innovation and Investment

China's relationship with the Silicon Valley/San Francisco Bay Area is unique, in part due to the deep historical and demographic ties between the Bay Area and China, but also because the region's technology sector—the world's largest—most highly concentrates the assets of technology, investment and expertise that relate to China's goals to accelerate its own technological development.

Bay Area technology companies, such as Intel, Apple, and Cisco, and venture firms, such as Sequoia Capital, DFJ (Draper Fisher Jurvetson), and Kleiner Perkins, have been active investors in China for decades. Now, reversing the historic trend in which virtually all investment flowed from the Bay Area to China, Chinese companies have started sending investment capital and other resources to the Bay Area through mergers and acquisitions, equity investments, and the establishment of research and innovation centers and accelerator programs. In this respect, they are following a path already well developed by companies from Europe, Japan, and elsewhere that are looking to participate in and leverage the Bay Area's innovation ecosystem.

As documented in the 2017 report *Chinese Direct Investment in California: 2017 Update*, produced by the Rhodium Group for the Asia Society and developed together with this report, California is the primary destination in the US for China's outbound investment, the majority which has been received in the last two years. The lion's share of this activity has come in the form of acquisitions, principally in the Bay Area and Greater Los Angeles. Most of that investment is in real estate, entertainment, and logistics, but the largest single field for investment is information and communication technology (ICT). That investment is concentrated principally in Silicon Valley, spread across semiconductors, IT equipment, and software. Though smaller, biotech is also a significant investment category, again concentrated in the Bay Area and in Greater Los Angeles. The Rhodium Group notes that in contrast to the rest of the United States, the great majority of Chinese investment in California (80%) comes from private investors (as opposed to state-owned companies) and is strategic in nature (88%), meaning that investments are made with long-term strategic goals as opposed to just seeking financial returns.[171]

China and the Bay Area

Chinese investors are coming to the Bay Area in growing numbers to invest in, partner with, and acquire technology startups. This parallels a trend in which Chinese companies are opening R&D centers around the world in order to embed themselves in national innovation ecosystems. As the world's leading technology, innovation, and entrepreneurial ecosystem, the Bay Area/Silicon Valley is a core focus.

The Asia Society's study tracks Chinese greenfield (non-M&A) investment in the Bay Area from the early 2000s, when initial entrants such as Huawei and China Telecom first opened offices. From a slow start, the pace of investment picked up between 2008 and 2011, as Chinese companies began an active pattern of mergers and acquisitions. Transactions included game developer Cryptic Studios (purchased by Perfect World), networking company UTStarcom (purchased by Beijing E-Town) and Solar Power Inc. (purchased by LDK Solar). Greenfield investment also continued to grow with the arrival of China Mobile and a surge of entrants in renewable and solar energy, as Chinese companies came to participate in California's growing solar market. New entrants included Trina Solar, Yingli Green Energy, Hanergy, GCL Solar, and China Sunergy. From 2012 to 2014, M&A activity intensified further, with acquisitions of solar cell producer MiaSolé by Hanergy, Motorola Mobility by Lenovo (which had already acquired significant assets in the Valley when it purchased IBM's personal computing division), and genome sequencing company Complete Genomics by BGI-Shenzhen. Since then, M&A activity has continued to grow, with acquisitions such as Hua Capital's purchase of digital imaging company Omnivision.[172]

Direct Investment

Aside from M&A, Chinese participation is also happening at scale in terms of direct investment. At the high end, many leading Bay Area technology companies have received substantial infusions of capital from Chinese investors, primarily through Chinese participation in funding rounds. China's leading internet companies are major players.

Example companies and the Chinese participation in their funding rounds[173] include the following.

Uber: A $1.6 billion round included Baidu (2015).

Lyft: A $680 million round included Alibaba Group and Didi Chuxing (2015).

Wish: A $514 million round included JD.com (2015).

SoFi: A $1 billion round included Renren (2015).

Airbnb: A $1.6 billion round included China Broadband Capital Partners, Hillhouse Capital Management, and Sequoia Capital China (2015).

Uber: Another $1 billion round, completed after Uber merged its China operations with Didi Chuxing in 2016, included Baidu, China CITIC Bank, China Life Insurance, Frees Fund, Guangzhou Automobile, Hillhouse Capital Management and Ping An Insurance Group.

Lyft: Another $1 billion round included Alibaba Group and Didi Chuxing (2016).

Unity Technologies: A $181 million round included China Investment Corp. and Frees Fund (2016).

Unity Biotechnology: A $116 million round included Wuxi Healthcare Ventures and Xiaomi Technology (2016).

Magic Leap received $795.5 million from Alibaba (2016).[174]

Jet.com received $500 million from Alibaba (2016).[175]

CloudMinds: A $100 million round included Beijing Venustech, Bojiang Capital, SB China Venture Capital, and Zhongguancun Development Group (2017).[176]

There have been many, smaller scale investments as well, which typically provide capital but also open doors to Chinese markets. Some examples include the following.

Skymind, an AI startup, has received funding from Tencent and other Chinese investors.[177]

Cloudflare, a web performance and security startup, has received investment from Baidu.[178]

Fyusion, a 3-D photography company, has a deal with Huawei; its technology is now on millions of Huawei's smartphones.[179]

Smule, a platform for creating and sharing music, received $54 million in a round led by Tencent as a precursor to expanding its product lines and marketing in Asia.[180]

Magento, an e-commerce platform spun off from eBay, received $250 million in a funding round led by Hillhouse Capital Management, also enabling its expansion in Asia (2017).[181]

Vivace Therapeutics, a biotech company developing cancer therapies, has investors from China including WuXi Healthcare Ventures, Shanghai-based Cenova Ventures, and Sequoia Capital China, along with the Bay Area's Canaan Partners and Mission Bay Capital.[182]

Quanergy, which develops light-detecting sensors used in driverless cars, raised funds in 2016 that included participation from partly-state-backed Chinese venture firm GP Capital.[183]

Kateeva, which makes machines that print flexible computer screens, raised $88 million in 2016 from Chinese investors including Redview Capital.[184]

Accelerators

Private and government Chinese entities have also joined a global trend by opening incubators and accelerators in the region. Examples include the following.

InnoSpring: China's first accelerator in Silicon Valley, InnoSpring is a partnership of Tsinghua University Science Park, Shui On Group, Northern Light Venture Capital, and Silicon Valley Bank. It has made 22 Bay Area investments, and its headquarters in Palo Alto hosts approximately 50 companies in its co-working space. Residents include InnoSpring portfolio companies, other US companies looking to enter China's market, and Chinese companies looking for US talent or technologies. Both Chinese and global venture firms such as Kleiner Perkins, Northern Light Venture Capital, GSR Ventures, China Broadband Capital, and Softbank are investors in the InnoSpring Seed Fund.[185]

Hanhai Silicon Valley Innovation Center: Originally named Hanhai Z-Park and principally focused on IT, the Hanhai Silicon Valley Innovation Center was established in San Jose in 2012 as a collaboration between privately-owned Hanhai Investment and Beijing's Zhongguancun Hanhai Technology Park. It now occupies 80,000 square feet and focuses on specific technology sectors, including AI, storage, new materials, semiconductors, robotics, mobile security, IoT, big data, clean energy, biotechnology and health care. In recent years, Hanhai has opened three other facilities in the region: a joint venture in San Francisco's Mission Bay district with QB3@953 (focused on biotech), a Burlingame facility (with 120,000 square feet), and a presence in Sunnyvale at Plug and Play. Sister incubators operate in Beijing as well as Los Angeles, Boston, Vancouver, Munich, Toronto, and Shenzhen. In addition to space, mentoring, and networking opportunities, residents may be introduced to partners who can open doors in Chinese markets and to Chinese VCs and, in most cases, they receive funding directly from Hanhai Investment. Since 2012, Hanhai's program of services for resident companies has included fully-funded trips to China for meetings with advisers and potential partners. Larger Chinese companies also use its facilities as bases when they plan investments or new R&D centers.[186]

HAX Accelerator: With offices in San Francisco and Shenzhen, HAX Accelerator is an arm of the HAX investment firm and offers end-to-end support for emerging hardware companies.[187]

New Silicon Valley Offshore Incubator: Slated to open in San Ramon in December 2017, New Silicon Valley Offshore Incubator will serve both Chinese and US entrepreneurs. The incubator is an initiative of Silicon Valley Global, a non-profit organization that facilitates exchanges between innovators in the United States and China.[188]

Shenzhen Valley Ventures: Based in Palo Alto, Shenzhen Valley Ventures (SVV) operates a hardware accelerator that provides startups access to testing equipment and a team of engineers as well as funding. It partners with Zowee, a factory in Shenzhen to offer design for manufacturing services. SVV invests in startups based both in China and in the US.[189]

TechCode: An early-stage investor and incubator, TechCode has 23 incubators in locations around the world, including Tel Aviv, Berlin, Helsinki, Seoul, Beijing, Shanghai, and Silicon Valley. Its AI+ Accelerator, available to startups located near its US offices, focuses on early-stage startups in artificial intelligence, robotics, and smart transportation. Candidate companies are expected to have a prototype, some traction, and the objective to scale globally—particularly in China. The accelerator is a strategic partnership with CFLD (China Fortune Land Development), a major investor and developer of new industrial Chinese cities.[190]

Shanghai Lingang Overseas Innovation Center: The Center is an extension of the Shanghai Lingang Economic Development Group, a state-owned company with diversified investments that focuses principally on industrial parks. In 2016, Shanghai Lingang acquired a 63,000 square foot building on Sansome Street in San Francisco, bringing 19 partner organization to co-locate there. The center is designed primarily to help Lingang Group's technology parks attract talent and go global.[191]

DayDayUp: Based in China, DayDayUp is a business community that connects Chinese and global investors, including an accelerator program that connects startups with potential partners. Its five co-working spaces include a facility in San Francisco.[192]

Bay Area accelerators, are also expanding their presence in China.

ReadWrite Labs: An accelerator in San Francisco that focuses on IoT, ReadWrite Labs offers a gateway program in Shenzhen that provides startups with mentorship and education about manufacturing in China, market strategies, and fundraising.[193]

RocketSpace: A San Francisco-based accelerator, RocketSpace raised $336 million in 2016 from HNA Group, a Chinese aviation conglomerate, to support growth at home and overseas, including support for early-stage tech companies looking for inroads in the Chinese market. Future locations are planned for Shenzhen and Beijing.[194]

Founders Space: Also headquartered in San Francisco, Founders Space opened facilities in Shanghai in 2016, and quickly went on to establish locations in Beijing and Wuhan. Shenzhen and Chengdu are next. Programs emphasize innovation and entrepreneurial education but include workspace, assistance in raising capital, and assistance in entering overseas markets. Assistance is also be available to US companies looking for a China presence.[195]

500 Startups includes early-stage Chinese companies in its Bay Area startup programs and works with later-stage Chinese companies looking to enter the US market, as well as later-stage US companies looking to enter China's market. Startups in its 500 Seed Program receive an investment of $500 thousand in exchange for 6% equity and $37.5 thousand in program fees.[196] 500 Startups maintains a presence in Beijing, Hong Kong, and Taipei, and will soon add Hangzhou to that list.

Corporate Innovation Centers

Like their counterparts from other countries, China's corporate innovation centers track technology trends in the region and partner with leading Bay Area companies. Some also have incubator or accelerator functions.

Alibaba Group currently maintains a modest presence in Silicon Valley through its venture arm and a data science team that focuses on cloud computing, both supporting activity in China. Its footprint is about to grow, however, through the company's recently-announced Alibaba DAMO Academy, which will operate seven new research labs around the world, including one in San Mateo. The Academy will also cooperate with UC Berkeley's RISE Lab on areas such as secured real-time computing.[197]

Baidu: For a number of years, Baidu has supported a Silicon Valley office with 200 employees in Sunnyvale, currently led by Baidu USA chairman Ya-qin Zhang, the former head of Microsoft's Asian R&D operations. The Silicon Valley center is primarily designed to help attract top AI talent, with autonomous vehicles—where the company is increasing its investment—a particular focus. Following the development and testing in China of a semi-autonomous vehicle with BMW in 2015, CEO Robin Li announced in 2016 a five-year goal to mass-produce autonomous vehicles. In the same year, the company received permission to test autonomous vehicles on California roads[198] and, with other companies in the field, is testing its vehicles at GoMentum Station, an AV testing facility in Concord.[199] In October 2017, Baidu announced that it would open a second R&D lab in Sunnyvale to focus primarily on self-driving cars. In addition to internet security research, the 36,000 square foot facility will support up to 150 employees and will house the company's Intelligent Driving Group.[200]

Dragon Group International, a company that distributes electronic components and semiconductor equipment, supports a Silicon Valley R&D center. Through its EoCell subsidiary, it is also engaged in the development of batteries and storage solutions, including next-generation lithium ion batteries and materials for use in cell phones, portable electronics, off-grid energy storage, and electric vehicles.[201]

Mindray: Shenzhen Mindray Bio-Medical Electronics Company, a leading developer, manufacturer, and marketer of medical devices, bases its North American Technology Innovation Center in Mountain View. Mindray supports seven R&D centers worldwide, and invests 10% of annual revenue in R&D. Its Bay Area presence builds on Mindray's 2013 acquisition of Mountain View-based ultrasound technology company ZONARE Medical Systems and its subsequently-established ultrasound Innovation Center in Silicon Valley.[202]

Tencent recently opened a data center in Silicon Valley, expanding its cloud-computing services into the US.[203] Tencent's Chief eXploration Officer is based in Silicon Valley, together with a Valley-based investment team.[204] The company also operates an AI lab in Seattle.[205]

ZGC Innovation Center @ Silicon Valley is run by ZGC Capital Corporation, a subsidiary of Zhongguancun Development Group. It aims to connect resources between China and the US and foster cross-border innovation. The center operates an overseas fund for Chinese investors, runs a startup incubator and accelerator, and offers cross-border services, such as consulting and public relations.[206]

Xuzhou Silicon Valley Science and Technology Exchange Center is an arm of the Yangtze Delta region city of Xuzhou.[207]

Zhejiang Innovation Center: Located in Santa Clara, Zhejiang Innovation Center, or ZJ Future, is a membership-based communication and information platform that produces reports for investors, researchers, and enterprises, on innovation and technology developments in China and the US.[208]

Startup Events

Among other activities, Chinese companies are sponsoring large startup events in the Bay Area. The Create@Alibaba Cloud Startup Contest (CACSC) is a competition where 12 competitively screened participants compete for two winning slots, with rewards including a $50,000 credit for Alibaba cloud products and services, the opportunity to receive up to $100,000 in investment from Hanhai Investment Group, and travel to Alibaba's home city Hangzhou to compete in the World Final at the Alibaba Cloud Yunqi Conference.[209] Other events include the Global Capital Summit, organized several times a year by venture capital platform F50, and the Silicon Valley Entrepreneurs Festival, first organized by Hanhai Holdings in May 2016, where more than 1,400 entrepreneurs, investors and speakers participated; the second SV Entrepreneurs festival was held in May 2017.

Venture Funds and Private Equity

Bay Area venture firms have been investing in China for many years. Some of the most prominent include the following.

DFJ DragonFund is the Chinese affiliate of Bay Area venture firm Draper Fisher Jurvetson. A joint venture between DFJ and Chinese partner DragonVenture, the fund focuses on early-and middle-stage China-centric technology companies. Established in 2006 with headquarters in Silicon Valley, it maintains management and consulting offices in Shanghai.[210]

GGV Capital: Founded on the idea of having a single team operating in both China and the US, GGV Capital is venture firm focused on the US and China as the world's two largest tech markets. With offices in Silicon Valley, Shanghai, and Beijing,[211] GGV invests in early- and late-stage technology companies, from seed through early Series A and B and growth.

Sequoia Capital China: The China arm of Menlo Park-based Sequoia Capital, with 100 people based at offices in Shanghai and Beijing, invests in seed, early-stage, and growth-stage companies.

Kleiner Perkins Caufield & Byers: KPCB's China advisory team, which operates independently from the Menlo Park-based venture firm, focuses on digital, green tech, and life sciences companies. It operates two offices in Shanghai, specializing in seed, early-stage, and growth companies.

DCM Ventures: With offices in Silicon Valley, Tokyo, and Beijing, DCM specializes in seed-, early- and mid-stage startups, with a focus on mobile, consumer internet, software, and services.[212]

Matrix Partners China: An affiliate of San Francisco and Boston-based Matrix Partners, the China fund invests across multiple sectors and stages.[213]

Bay City Capital–GF Xinde Life Sciences Fund: A Cayman Islands-based partnership of San Francisco's Bay City Capital with China-based GF Xinde, the fund—announced in 2017—will invest in innovative biopharma companies.[214]

CSC Upshot: A US-based $400 million seed fund that invests primarily in AngelList syndicates, CSC Upshot is managed by Hone Capital (a subsidiary of CSC Group, one of China's top three private equity firms) and Upshot Ventures.[215]

Angel investors from the Bay Area have also been visiting China, including Hong Kong, seeking investment opportunities. Angel investors associated with Keiretsu Forum, Band of Angels, Sand Hill Angels, and Tech Coast Angels have become active investors, sometimes in association with Chinese incubators and accelerators such as InnoSpace, InnoSpring and Chinaccelerator.

Silicon Valley Bank, which works extensively with startups, has pioneered China's early-stage investment environment through SPD Silicon Valley Bank,

the first Sino-American joint venture bank in China. The bank' s ownership is 50% by Shanghai Pudong Development Bank (SPDB) and 50% by Silicon Valley Bank (SVB). Grounded by SPDB's experience working with local Chinese companies and by SVB's experience working with innovation companies, SPD Silicon Valley Bank offers specialized commercial banking services specifically for innovative companies and their investors in China, through offices in Shanghai and Beijing, and soon in Shenzhen.[216]

Shifting the historical pattern of a one-way flow to China, Chinese venture firms are now becoming active investors in the Bay Area.

Amino Capital: Formerly zPark Capital, Amino launched its first fund in 2012, focusing on seed and pre-A round, and invested in 39 startups. Headquartered in Silicon Valley, its $50 million second fund, which closed in 2016, also includes Series A and B investment, with a focus on artificial intelligence and data-driven ventures. Dr. Huican Zhu, a pioneer of image and Asian-language search at Google and the former chief architect and general manager of Tencent's cloud infrastructure, joined Amino in 2016 as a general partner.[217]

Baidu Ventures-Comet Labs Partnership: To support its drive to build an ecosystem around AI technology, Baidu Ventures has partnered with San Francisco-based Comet Labs, a fund that specializes in machine intelligence. The partnership will connect Comet Labs' portfolio companies with partners and markets in China. Baidu Ventures will contribute resources to Comet's accelerator programs, and both companies will provide mentorship and investment to AI startups.[218]

Fosun RZ Capital: Backed by the Fosun Group, Fosun RZ Capital focuses on healthcare, fintech, education, B2B, automotive IT, internet-based consumer and business services, and IoT. With offices in Shanghai, Shenzhen, New Delhi, Bangalore, and Silicon Valley, it invests in angel through growth stages.[219]

GSR Ventures: China-based GSR focuses on early stage technology companies. The firm was the first institutional investor to invest in Didi Chuxing, and manages a $1.5 billion portfolio through a combination of USD and RMB denominated funds.[220]

Hone Capital: Formerly known as CSC Venture Capital, Hone is the US arm of the CSC Group, one of China's largest private equity and venture firms. CSC Group was founded in 2015 in Shenzhen as China's first large private equity firm and currently has more than $10 billion in assets under management. With US headquarters in Palo Alto, Hone has invested more than $100 million since 2015 in early- to growth-stage companies in the technology sector.[221]

New City Advisors: Headquartered in Campbell and with an office in Beijing, New City aggregates funding from private Chinese investors, many of them entrepreneurs, focusing on acquisitions. The $6 billion fund, which invests in consumer products and services, advanced manufacturing (robotics), medtech, and telecom, placed approximately $200 million in 2016 and works with a network of industrial partners in China that are looking for acquisitions to help them grow. The relationships that result also help portfolio companies to more efficiently compete in Chinese markets.

New Horizon Capital: A China-based private equity fund, New Horizon focuses on companies with strong underlying fundamentals and high growth potentials, particularly in less developed areas of China, while also actively seeking investment opportunities in the Tier I cities and regions of China's more developed eastern areas.[222]

Pivotal bioVenture Partners: Launched in 2017, Pivotal invests in early-stage drug, medical device, diagnostic, and therapeutics companies. A US firm, Pivotal is backed by Nan Fung Group, a Hong Kong company that originally focused on real estate, hotels, and shipping and is expanding into life sciences. Pivotal's managing partner is Nan Fung COO Vincent Cheung, who is a grandson of the company's founder and who studied biochemistry at UC Berkeley.[223]

Sinovation Ventures: A China-based venture firm with US headquarters in San Francisco, Sinovation focuses on early-stage companies in IoT, robotics, edtech and software. Founded in 2009 by Kai-fu Lee and with offices in Beijing, Shanghai, and Shenzhen, it currently has $1.3 billion in assets under management

between five USD and RMB funds and a portfolio of over 300 companies in China and the United States. In the US, the firm invests at the seed, Series A and Series B stages, based primarily on companies' potential for growth in both the US and Chinese markets. As an investor, the firm serves as a go-to-market partner for its companies, transferring lessons from its China portfolio into its US practice.[224]

Tsing Capital: A Chinese venture firm, Tsing Capital focuses on multidisciplinary sustainable technology investment in China and globally. Areas of activity include environment, clean energy, new materials, advanced manufacturing, sustainable mobility, sustainable agriculture, and future cities.[225]

SAIC Capital: The Silicon Valley-based venture arm of state owned automotive company SAIC invests in early- and growth-stage companies in the transportation sector, including alternative energy, human-machine interaction, and connected vehicles.[226]

Shenzhen Capital Group Co. Ltd. is a Chinese venture capital firm founded by the Shenzhen Municipal Government in 1999. It invests in innovative companies overseas, including some startups in the US.[227]

WestSummit Capital: A US-focused growth capital venture fund, WestSummit is operated by former entrepreneurs, CEOs, and executives of Nasdaq-listed companies in Silicon Valley and China. With offices in Menlo Park, Beijing, and Hong Kong, its capital comes principally from Chinese and other sovereign wealth funds. Now investing from its third fund, WestSummit also helps its portfolio companies establish relationships and develop markets in China through access to prospective customers, partners, and capital, as well as assistance with options in China for manufacturing, talent sourcing, and M&A.[228]

ZhenFund: A collaboration of New Oriental co-founders Bob Xu and Victor Wang with Sequoia Capital China, Beijing-based ZhenFund promotes innovation among youth in China, with a primary focus on Chinese students returning from abroad who may become company founders.[229]

The Bay Area is also seeing increased interest from Chinese angel investors who are looking to invest in US technology companies and in some cases cooperate to bring their IP, products, and technology to the Chinese and Southeast Asian markets. As an example, the Keiretsu Forum (the world's largest angel investor network) is seeing members from its Chinese chapters visiting the Bay Area increasingly often to attend angel group meetings and other events where US companies raise funding. Chinese angel investors are also looking for investment opportunities on crowdfunding platforms including AngelList and through early stage funds administered by 500 Startups, Keiretsu Capital, and RocketSpace, as well as through other emerging mechanisms.

University Research Partnerships

University collaboration is another aspect of the Bay Area-China technology relationship. An example is the *Tsinghua-UC Berkeley Shenzhen Institute* (TBSI). Established in 2014 as a collaboration of Tsinghua University, the Shenzhen municipal government, and UC Berkeley, TBSI is a joint science and technology research and graduate education platform that offers dual degree programs. Headquartered in Nanshan Intelligence Industrial Park in Shenzhen, it has offices and laboratories at the Graduate School at Shenzhen, Tsinghua University, and UC Berkeley. Its principal areas of focus include environmental science and new energy technology, information technology and data science, and precision medicine and healthcare. PhD and Masters degree students are co-advised by faculty at Tsinghua and UC Berkeley.[230]

Stanford Center at Peking University serves as the base for Stanford students and faculty conducting research in China. It does not offer degrees, but enables Stanford faculty to collaborate and teach classes with Peking University faculty. The center is used by ten Stanford programs and departments, including the Graduate School of Business.[231]

Looking to the Future

On the question of whether China is innovative, the answer is yes but with qualifications. Weak IP protection constrains innovation by Chinese as well as foreign companies doing business in China. China lacks a vibrant international community comparable to Silicon Valley's, where entrepreneurs and scientists from around the world can contribute. And large scale investment, public or private, doesn't necessarily lead to innovation. Money alone can't buy innovation, which is deeply rooted in business culture.

China has succeeded in producing at scale private companies that dominate Chinese markets and are entering global ones. For the most part, its brand of innovation is not based on breakthrough technologies or deep scientific research. It is more about incremental and business model innovation, where products and services are developed based on a nimble reading of Chinese consumers and are deployed at scale. But as China's government continues to invest heavily in scientific research and training, and as Chinese companies invest more of their considerable resources in R&D, China's science-based innovation can be expected to grow as well. Where China is not a leader today, it may be in the future.

The question of Chinese innovation is complicated, however, by the government's role. Like most governments around the word, China supports scientific research and seeks to develop its domestic talent pool. To a degree that far exceeds other countries, however, it also pursues a suite of industrial policies explicitly designed to create national corporate champions, extract technologies from foreign investors, and protect Chinese markets from overseas competitors in strategically selected industries. China is also different because of the guiding role of the Communist Party, whose influence extends to every corner of the economy, including private companies. Through both incentives and disincentives that reflect the Party's political and economic priorities, the resources of the Chinese economy are orchestrated to support centrally-directed objectives. In this respect, doing business with Chinese companies is different from doing business with companies from Japan, Canada, or Germany, and it is difficult to consider questions of either innovation or investment independently of the goals of China's government.

While state-owned companies usually lag in productivity and innovation, many of China's private companies are innovative and highly competitive; competition between Chinese companies is intense, and foreign companies doing business in China must compete in the same environment. But many Chinese technology companies, particularly in strategic industries, have also developed in a hothouse environment that has enabled their domestic growth with little or no foreign competition. Having achieved scale in China—perhaps the only country besides the United States big enough to enable companies to reach global scale purely within its own domestic market—these companies are now poised to compete globally.

When doing business in China, US technology companies therefore face complex options. Strategically, they can choose to invest and partner, leveraging market scale and innovative capacity and sharpening their global edge by competing on China's home turf. Many fear they may lose out on opportunities for innovation by not being there. This, however, entails calculated risks around the loss of IP, either through required technology transfer or weak IP protection. The attraction of China's market can be compelling, but companies also must consider whether their core technology can be protected, and whether their position in the Chinese market can be sustained if that technology is compromised by competitors. While few US companies are leaving China, government policies and weak IP protection have caused many to keep their best technology at home and others to stay away.

This discussion carries overseas, as Chinese companies become increasingly active investors. Chinese companies that invest overseas generally behave the same as any foreign investor, seeking to develop new markets, increase their revenue, and acquire technologies that will help them up their game and become more competitive. They are not, as a rule, extracting technologies or hollowing out the companies they invest in. On the contrary, Chinese investments provide significant capital and often help the companies they invest in to more efficiently compete in Chinese markets. These relationships have proven mutually beneficial and should be welcomed and expanded. There remains, however, a larger question of whether

Chinese investment in US technology companies will lead to the transfer of intangible assets and know-how to China, that will create stronger Chinese competitors over time and erode the United States' long-term innovation advantage.

For the US government, China's technology trajectory presents a different set of issues regarding the pervasive influence of China's government at both the macro and the micro levels of its economy. This is reflected in growing demands from the United States and other countries for greater reciprocity in market access and investment opportunity in China. Chinese cloud companies, for example, can freely operate in the US, but US cloud service providers operating in China are essentially required to turn over ownership and operations to Chinese partners, potentially transferring valuable IP and know-how.[232]

In an unpublished white paper prepared by the Defense Innovation Unit Experimental (DIUx), the US Defense Department's Silicon Valley arm, concerns have also been raised that Chinese acquisitions of—or investment in—startups with advanced technology might accelerate technology transfer in ways that could advance China's military capacity. In response, proposals are pending in Congress that would expand the authority of the Committee on Foreign Investment in the United States (CFIUS) to conduct national security reviews not only of foreign investment in large US companies, as it does now, but in investments in startups with advanced technology as well. Separately, the Trump Administration is considering trade measures—a WTO complaint or unilateral action through Section 301 of the Trade Act of 1974—to force China to reduce intellectual property theft and modify the rules that force technology transfer to Chinese companies as a condition of market access.

It is still unclear whether the strong role of government will ultimately help or hurt Chinese innovation, though most likely it will do both. It will help as resources are mobilized on a large scale to advance national objectives, including China's leadership in key technology sectors. But the same guiding hand, and efforts to further restrict access to information, can hinder innovation by misallocating resources, discouraging disruptive thinking, limiting both the internal and cross-border sharing of information and ideas, and shielding Chinese companies from the stimulative effects of foreign competition. Universities, where party supervision and the presence of Party committees constrains free thought, are also affected.

This puts US investment in China and Chinese investment in the US at a crossroads. The United States and California—and Silicon Valley in particular—benefit strongly from Chinese investment and partnerships. University collaborations are deep, research labs generate new IP, Chinese cities with innovation districts and civic intermediaries in California actively provide portals and supporting services, and shared interests in issues such as energy and climate change bridge both economies.

Private investment brings resources and market knowledge from which US companies benefit. That door should remain open. But it is increasingly clear that issues of balance and reciprocity in market access and China's compliance with its WTO commitments, in letter and in spirit, must be confronted directly.[233] A stronger presence and more level playing field for California and Silicon Valley companies in China can advance China's innovation goals, through shared research and product development and by challenging Chinese companies to meet the highest quality and service standards. A more level playing field is in the interest of both countries.

For their part, Chinese companies are demonstrating increased prowess in leveraging China's market scale, internal investment, foreign technology, and government support to accelerate innovation-led growth. The best can be strong partners, as well as increasingly formidable competitors. As China's already considerable innovative capacity grows, this will present challenges as well as opportunities for Bay Area/ Silicon Valley technology companies. Either way, every company will need a China strategy or a global strategy that takes China into account. Both sides can benefit from an open door. Business decisions and government policy will determine whether this leads to increasing conflict or to expanded partnerships between the world's two largest economies.

Appendix

Interviews and Informational Support

Advisors

Peter Fuhrman, Chairman & Founder, China First Capital (Shenzhen)

Matthew Le Merle, Co-Founder and Managing Partner, Fifth Era and Keiretsu Capital

Chenyang Xu, Co-Founder & Co-Chair, Innovation Executive Forum, and IEEE Fellow

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Jim Myrick, Entrepreneur-in-Residence, RocketSpace and Entrepreneur-in-Residence, Flex

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Ken Wilcox, Chairman Emeritus, Silicon Valley Bank

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Edith Yeung, Partner and Head, Greater China, 500 Startups

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