GLOBAL CHINA: TECHNOLOGY

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China's rapid technological advances are playing a leading role in contemporary geopolitical competition. The United States, and many of its partners and allies, have a range of concerns about how Beijing may deploy or exploit technology in ways that challenge many of their core interests and values. While the U.S. has maintained its position as the technologically dominant power for decades, China has made enormous investments and implemented policies that have contributed significantly to its economic growth, military capability, and global influence. In some areas, China has eclipsed, or is on the verge of eclipsing, the United States — particularly in the rapid deployment of certain technologies.

These dynamics are enmeshed in a broader context of U.S.-China tensions; U.S. alliance management challenges; complex and shifting global supply chains; debates over economic and technology "decoupling"; tensions between norms of research openness and concerns about technology transfer; a contest for global technology standard-setting; rapid technological development in other countries, particularly in East Asia; and transnational debate about the regulation of large technology firms.

There is also an important debate about the relationship between China's record of achievement in meeting its ambitions and what that record says about the long-term prospects for its development of key technologies. While some analysts focus on the persistent gap between the rhetoric of Beijing's five-year plans versus its actual achievements, others point to an overarching record of extraordinary progress. The Chinese Communist Party's ambition to "catch up with and surpass" the West in advanced technologies is hardly new. It traces a lineage in Party guidance from Mao Zedong to Xi Jinping, with an emphasis on technology as a source of national power and key domain of international competition, and "indigenization" as a top priority. But as China's economic and political influence have expanded, so, too, have many of its technological ambitions and achievements.

The COVID-19 pandemic and the global economic shock in its wake are also likely to impact, if not profoundly shape, many of these dynamics in foreseeable and unforeseeable ways.

This installment of papers for the Brookings Foreign Policy project "Global China: Assessing China's Growing Role in the World" assesses China's growing technological reach in the world by focusing on both thematic and technology-specific topics. Thematically, the papers explore the broad dynamics of U.S.-China technology competition, the relationship between the regulation of large U.S. technology firms and strategic competition with China, technology transfer and alliance management, and China's role in the global competition for technology talent. On specific technologies, our contributors assess China's progress in the development of fifth-generation (5G) wireless technology, weapons enabled by autonomy and artificial intelligence (AI), power grid cybersecurity, financial technology, biotechnology, surveillance technologies, semiconductors, and space technology. They examine China's ambitions, obstacles, and achievements, and recommend policy options for the United States and its partners and allies.

Michael Brown, Eric Chewning, and Pavneet Singh argue that the United States is in a "superpower marathon" with China, an economic and technology race in which the U.S. must compete with — rather than contain — China. Brown, Chewning, and Singh emphasize the degree to which technology and innovation will drive U.S.-China economic competition and the U.S. role in the world. They advocate a strategy designed to improve U.S. competitiveness and focus on long-term capability development. In particular, they propose larger investments in research and development (R&D) including a focus on engineering talent, an integrated U.S. economic strategy across government, and longer-term focus for U.S. businesses and capital markets.

Tom Wheeler argues that, if the United States is to "out-innovate" China, it must embrace competition-driven innovation and "reorient our industrial age thinking to embrace policies that take advantage of the non-rivalrous nature of data." For years, some of America's largest technology companies have argued that the best strategy to manage the technology challenges posed by China is to allow them to "expand their already dominant marketplace positions, and to resist regulation." Wheeler makes the case that entrepreneurs must be able to access "digital assets that have been locked away by the dominant companies," in a manner that protects privacy. He urges legislators and regulators to more vigorously protect consumers and competition, and to define the challenges posed by AI less in terms of "implementation," where China has an advantage, but instead through the lens of innovation, where he argues the U.S. retains the advantage. He advocates an approach that does not mimic Beijing's embrace of national champions and avoids "the 'China doesn't regulate their companies that way' smokescreen," but instead embraces "the all-American concept of competition-driving innovation."

Elsa B. Kania focuses on Chinese advancements in "intelligent" and autonomous weapons systems. The Chinese military and defense industry have undertaken major initiatives in research, development, and experimentation in autonomy and AI-enabled weapons systems that could threaten global security and stability, particularly as U.S.-China rivalry intensifies. China continues to sell weapons systems to U.S. adversaries and militaries with poor human rights records, undermining U.S. values and risking the further diffusion of these weapons systems to malicious non-state actors. However, China's progress will be contingent on its ability to overcome significant hurdles to testing, training, and application in real-world scenarios. As China seeks to leverage innovation in the science and technology fields in pursuit of great power status, it will also face building pressure to more seriously address emergent safety, technical, legal, and ethical considerations. Kania argues that the United States must closely monitor Chinese military and technological advancements in this area, exercise caution when disclosing new U.S. capabilities, and engage in dialogue with allies and partners as well as Chinese military counterparts to reduce the risk of unintended escalation.

Nicol Turner Lee notes the stakes of an intensifying competition between the United States and China to deploy 5G wireless networks. She argues that, in this competition, the United States and China have taken very different approaches in developing these networks. In particular, she surfaces the risks of a "split digital ecosystem worldwide" spurred by China's Belt and Road Initiative, and the potential for China to "lock in" other nations with its 5G technology. In the United States, bureaucratic delays restrict access to 5G spectrum and rising national security concerns surrounding Huawei, China's dominant 5G player, are impacting the global supply chain. In particular, she identifies tensions between U.S. diplomacy on Huawei, legacy network interdependence, and cost structures. Despite China's slight lead in the areas of spectrum and equipment, however, Turner Lee notes that the U.S. historically has maintained dominance over innovation and could make up for lost time with a more coordinated 5G strategy. She recommends that the United States pursue more flexible and timely spectrum policies, scalable alternatives for 5G equipment, and a long-term plan — including of increased R&D spending — to develop future platforms enabled by advanced mobile networks.

Aaron Klein documents that, "whereas America led the global revolution in payments half a century ago with magnetic striped credit and debit cards, China is leading the new revolution in digital payments," moving to a system based on smartphones and QR codes (two-dimensional bar codes), in which traditional

banks play a diminished role. WeChat Pay and Alipay, based on social media and digital commerce platforms respectively, are China's primary digital payment systems. The powerful reach of these platforms — combining information on social connectivity and financial flows between and among individuals and firms — opens up a new range of possibilities, and major concerns regarding privacy. Klein also notes the potential for anti-competitive behavior. He suggests that digital payments are unlikely to catch on in the United States and other countries where "the payment system is skewed to providing substantial rewards to wealthier consumers, through tax-free rebates on high-end credit cards," but may be more viable in other countries with less-developed banking systems. Klein notes that countries that receive large numbers of Chinese tourists face pressure to offer Chinese digital payment options, and that "the overall outcome seems clear: Chinese payment systems will increasingly be integrated into global payments."

Sheena Chestnut Greitens focuses on the growing adoption of China's public security and surveillance technology platforms around the world. Huawei boasts in its 2018 annual report that its "Safe City" projects are "in 700 cities across more than 100 countries and regions." Greitens finds that there is relatively little correlation between such platform adoption and the levels of democracy or freedom in adopting countries, and that both "push" and "pull" factors appear to be driving the adoption of this technology. Major questions remain about the implications and advantages that China could derive from its activities in this sector, and Greitens argues U.S. policymakers will need a nuanced approach to the tradeoffs that leaders in adopting countries confront. While there are concerns about how these technologies could contribute to the entrenchment of authoritarian rule in some countries, or the weakening of democratic norms in others, many leaders in adopting countries also see potential for these platforms to solve urgent public problems, such as violent crime. Greitens also argues that U.S. policymakers must address Chinese technology companies' often quiet initiatives to shape the global regulatory environment. She recommends that the United States urgently propose a set of standards that are compatible with U.S. values — respect for human rights, civil liberties, privacy, and democracy.

Remco Zwetsloot explores China's approach to global technology talent competition. He describes China's strategy to grow its science and technology talent as: 1) improving domestic education; 2) attracting overseas Chinese talent; and 3) attracting foreign talent. While China's commitment to domestic education reform has achieved remarkable results — science and engineering degrees granted by Chinese universities more than quadrupled from 360,000 in 2000 to 1.7 million in 2015 — there remain significant challenges associated with instructional quality and employment opportunities for many graduates. Attracting and retaining talent from abroad has proven particularly challenging. Zwetsloot also highlights the dilemmas faced by other countries in responding to China's talent ambitions. China is the world's biggest source of foreign-born talent, and countries often compete to attract Chinese talent to their universities and firms. But, as China has focused on attracting returnees, there have been growing concerns about the implications for competitiveness and national security. Zwetsloot warns of three potential pitfalls for U.S. policymakers responding to China's technology talent initiatives. First, the United States' ability to retain Chinese talent is a challenge to China's technological ambitions, so the U.S. should avoid restrictions that undermine this advantage. Second, unilateral U.S. actions designed to minimize technology transfer could simply channel Chinese talent to other countries; the U.S. should therefore coordinate technology transfer and related policies with its allies and partners. Third, the U.S. must not only adopt defensive measures, but also affirmative domestic education and immigration reform. Chinese strategists, Zwetsloot notes, explicitly cite restrictive U.S. immigration policies as "opportunities to bolster" China's AI talent, and meaningful U.S. immigration reform as posing "a huge challenge" for China's talent ambitions.

Andrew Imbrie and Ryan Fedasiuk assert that the United States and its allies must develop targeted and coordinated policies to respond to unwanted Chinese technology transfer, as part of a broader agenda of technology alliance cooperation. Analyzing scholarship programs, technology entrepreneurship competitions, and foreign direct investment as vehicles for technology transfer, Imbrie and Fedasiuk recommend that the U.S. and its allies should assess "the potential risks to [their] economic security, the resilience of

American and allied companies to withstand potential reprisal and loss of market share, and the rules of the road that will protect liberal democratic values and strengthen long-term economic competitiveness." Imbrie and Fedasiuk recommend that the U.S. and its allies gather more data, raise greater awareness of the variety of vehicles China uses for technology transfer, and coordinate investment screening procedures.

Scott Moore explores China's trajectory in the global biotechnology sector. While the United States has been the dominant global player in developing and commercializing biotechnology for decades, China is determined to become a leading player in biotechnology and is investing heavily in the sector. Moore argues that, while the U.S. is likely to remain ahead in most biotechnology fields, China's biotechnology sector can still be expected to produce significant innovations in coming years, and the Chinese market will increasingly inform global biotechnology research, development, and commercialization. China is therefore poised to become a critical player in policy and governance issues related to biotechnology, even as it works to overcome deficiencies in research and development and higher-risk financing. Several national security concerns attach to the maturation of China's biotechnology sector, including military uses of human performance enhancement and synthetic bioweapons production, the collection and use of biomedical data on American citizens for espionage or other nefarious purposes, and access to and control over biomedical data, which could fuel AI for biomedical applications, and shape the economic competitiveness of the U.S. biotechnology sector. However, Moore also suggests avenues for cooperation, including in the wake of the COVID-19 pandemic. Shared interests in biosafety and biosecurity protocols also could open channels of cooperation in the way that shared concerns about nuclear security and nonproliferation did in previous decades.

Frank A. Rose outlines how China has rapidly expanded its presence in outer space in both the civil and military arenas. China's People's Liberation Army has conducted a major reorganization to better integrate space, cyberspace, and electronic warfare systems with its other military capabilities. Rose argues that, in light of these developments, the United States will need to develop a strategy that deters China's advancing anti-satellite (ASAT) capabilities, while also addressing sustainability and safety concerns like orbital debris, space traffic management, and the rise of mega-satellite constellations. The United States will also need find a *modus operandi* for engaging with China on civil space projects while safeguarding national security interests. Rose outlines several recommendations, including a dialogue on civil space and space security issues, enhancing deterrence against Chinese ASAT threats, and efforts to agree on norms of behavior for outer space.

Tom Stefanick argues that the United States' and China's mutual concern about the security of their increasingly complex electrical grids could provide an opening for mutual restraint on activities perceived as threatening each other's grid networks. Stefanick highlights the strategic significance of these networks, and the accompanying gravity of cybersecurity risks, particularly as the United States and China take steps to connect their grids to the internet. China is now the world's largest electricity producer by far, producing at least 70% more electric energy in 2019 than the United States. While China has been developing and fielding an array of technology management approaches to grid security, Stefanick focuses on the application of AI and, in the future, the potential for quantum applications as well. He distinguishes China's and Russia's approaches to grid security, highlighting Russia's cyberattacks on Ukraine's power grids.

Saif M. Khan and Carrick Flynn address China's ambitions, achievements, and obstacles in developing an indigenous semiconductor industry, and argue that it is in the strategic interest of the United States and democratic allies and partners for China to remain reliant on them for state-of-the-art computer chips. China is investing heavily to produce advanced chips that can power weapons systems that could threaten the U.S. and its allies and partners, as well as techno-authoritarian surveillance that violates human rights. Khan and Flynn recommend coordinated, multilateral export controls (with Japan and the Netherlands in particular) on semiconductor manufacturing equipment to slow, if not halt, China's progress toward producing advanced chips, and thereby inhibit China's development and use of dangerous or otherwise concerning technologies. Because the U.S., Taiwan, and South Korea are currently the only economies

with significant, near-state-of-the-art chip fabrication factory capacity, and because global chip demand is arguably independent of where chips are produced, Khan and Flynn argue that the export controls they prescribe would, over the long-term, shift a significant portion of China's lost chip fabrication capacity to democracies.

Together, these assessments illustrate that technological developments both reflect and inform strategic competition between the United States and China, and broader alliance management challenges that the U.S. must address to maintain a favorable balance of power vis-à-vis a rising China. They document China's extraordinary investment and progress in many technological domains, as well as persistent obstacles to achieving sometimes longstanding ambitions. They reveal critical linkages between foreign and domestic policy through the strategic and cross-border reach of domestic technology policy and regulation, as well as the domestic impacts of global standard-setting initiatives. Finally, the contributors to this series have assembled an impressive and ambitious agenda for U.S. and allied competitiveness that merits close attention from policymakers in the United States and around the world.

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