SECTION 2: THE CHINESE COMMUNIST PARTY'S ECONOMIC AND TECHNOLOGICAL AMBITIONS: SYNTHETIC BIOLOGY, NEW MOBILITY, CLOUD COMPUTING, AND DIGITAL CURRENCY

Key Findings

- The Chinese Communist Party (CCP) views achieving technological self-sufficiency as essential for both economic growth and political survival. China's leaders believe they can rely on the domestic development of emerging technologies not only to address long-term structural challenges such as falling productivity growth, demographic decline, and environmental degradation but also to strengthen Party control and stability while reducing dependency on foreign technology and products.
- Under General Secretary of the CCP Xi Jinping, the Party has increased its control over China's economy in ways that have further enhanced the links between China's state and nonstate sectors. The CCP believes state control rather than economic liberalization is essential to achieving economic growth while maintaining political stability.
- To achieve dominance in emerging technologies like cloud computing, synthetic biology, and new mobility, Chinese policymakers are relying on extensive subsidization and other tactics similar to those previously used for industries such as shipping, telecommunications, and conventional vehicles. With few internationally accepted standards or rules, Chinese companies and other entities are actively shaping standards in collecting, protecting, and governing data. Chinese efforts to build technological capacity could have lasting negative consequences for the future of U.S. technological leadership.
- The CCP is working to establish China as a global leader in synthetic biology, motivated by the prospective economic benefits and also the potential for synthetic biology to mitigate structural problems such as deficiencies in China's healthcare system and scarce natural resources. The United States leads in most applications of synthetic biology, but Chinese synthetic biology firms receive generous state subsidies and have begun supplementing domestic genomic data collection with international collection efforts.
- With its advancements in new mobility, China is positioned to contest U.S. leadership in various technologies. The Chinese government has prioritized development of new energy vehicle (NEV) technology through extensive subsidies and protection-

ist policies while capturing every stage of the supply chain for NEV batteries. In autonomous and connected vehicles, global competition is increasing as Chinese companies are engaged in pursuit of international markets.

- U.S. global dominance in cloud computing may be challenged by Chinese competitors in developing markets. Chinese cloud computing companies have thrived in a protected home market and with few exceptions can operate freely in the United States while U.S. companies face barriers in China. Protecting its cloud computing sector to control information and data flows is a national security priority for China as well as a strategic imperative to support other key emerging technologies such as new mobility, artificial intelligence (AI), biotechnology, smart cities, and big data applications.
- China leads among major economies in the development of a central bank digital currency. The CCP's promotion of a digital renminbi (RMB) is motivated by several factors, including a desire to increase control and surveillance of financial transactions by state and nonstate companies, foreign firms operating in China, and individuals. China's digital RMB does not present an immediate challenge to the U.S.-led global financial system, but in the long term it could undermine the status of the U.S. dollar and efficacy of U.S. financial sanctions.

Recommendations

The Commission recommends:

- Congress direct the U.S. Department of Energy, in coordination with the National Institute of Standards and Technology and other relevant agencies, to produce a report and research plan outlining a project for the collection and sequencing of nonhuman genomic data, analogous to the Human Genome Project. Such a plan shall include:
  - A description of the types of nonhuman genomic data to be collected and sequenced;
  - An explanation of research value and commercial applications from collecting and sequencing such data;
  - The designation of an existing Department of Energy National Laboratory to coordinate the project and award grants to U.S. universities and private companies in furtherance of the project's goals;
  - A description of ethical considerations and processes for stakeholder engagement; and
  - Articulation of the National Institute of Standards and Technology's role to:
    - Codify technical standards related to the project;
    - Share and protect data collected during the project; and
    - Engage with the public and international partners on the project's findings.

- Congress direct the National Institute of Standards and Technology, in coordination with the National Institutes of Health, the U.S. Patent and Trade Office, the Department of Energy, and the Department of State, to establish a model framework for the protection, collection, and commercialization of nonhuman genomic data. The framework should seek to establish principles on intellectual property rights for the countries of origin of the genomic data. This framework should also be used in international outreach regarding protection of national biotechnology assets and Chinese predatory collection of data.
- Congress request a report from the Administration regarding data servicing operations owned by Chinese firms. Such a report shall include:
  - Whether such firms are operating in the United States, what laws and regulations may apply to such operations and services, and what cloud computing services are offered or provided to U.S. persons;
  - Whether Chinese cloud computing providers are engaged in any joint ventures or servicing arrangements with U.S. firms and the nature of such operations;
  - Whether consumers of these services have access to prominently identified information regarding the ownership of such cloud computing services;
  - Whether U.S. firms can operate freely in the People's Republic of China (PRC) and what, if any, restrictions might apply to their services and operations;
  - Where Chinese-owned firms may be providing equipment or services for the provision of cloud computing support in third-country markets and whether the market share of Chinese-owned firms in those markets may limit, in any way, the ability of U.S.-owned firms to operate independently of such operations; and
  - What support the Chinese government may be providing to cloud computing firms in terms of equipment and services that may act as a subsidy for such operations.
- Congress consider legislation requiring that the U.S. Department of Transportation, in consultation with the U.S. Departments of Commerce, Energy, and Defense, and law enforcement authorities, develop regulations limiting access for Chinese-owned firms developing autonomous vehicle capabilities to protect U.S. national and economic security interests. In preparing such regulations, the authorities should consider the extent to which the Chinese government limits access of U.S. firms for similar uses. Specific attention should be given to data collection activities that may advance the interests of the Chinese military or intelligence agencies. In addition, such legislation shall address any need to protect the data utilized and collected by autonomous vehicles produced and/or serviced by Chinese-owned firms.
- The committees of relevant jurisdiction in the House and Senate investigate and hold hearings with a view toward consider-

ing legislation on the operations of China's Blockchain-Based Service Network, with particular attention to its operations in the United States and participation of U.S. companies in building out the network. Such investigation should look at the goals of the network in developing blockchain infrastructure and whether the involvement of the Chinese government and Chinese state-owned entities may put at risk any U.S. economic and national security interests.

- Congress consider legislation to create the authority to screen the offshoring of critical supply chains and production capabilities to the PRC to protect U.S. national and economic security interests and to define the scope of such supply chains and production capabilities. This would include screening related outbound investment by U.S. entities. Such legislation would direct the secretaries of defense and commerce, along with the U.S. Trade Representative, to develop procedures to evaluate existing and proposed supply relationships with the PRC and identify whether critical U.S. interests are being adversely affected, including the loss of domestic production capacity and capabilities. The legislation would authorize the president to take appropriate action, including prohibiting supply relationships or certain transactions to protect U.S. national security.

Introduction

In the 14th Five-Year Plan (FYP)* (2021–2025), the CCP articulates a vision for economic prosperity that ensures social stability and its paramount control while promoting a "modern socialist country."[1] While the 14th FYP builds on policy ambitions previously articulated by the Chinese government, one of its most significant changes is that it drops precise numerical growth targets. Instead, mounting socioeconomic challenges—from pollution to rising income inequality—are critical factors in motivating the CCP's focus on delivering quality-of-life improvements. The 14th FYP also looks beyond its five-year remit to longer-term objectives, framing the 2021–2025 period as the latest stage in a longer economic and social development project mapped out to both 2035 and 2049.†[2]

At the same time that it articulates an ambitious growth agenda, the CCP acknowledges overwhelming domestic obstacles. Achieving indigenous technological breakthroughs is a particularly urgent challenge, driven by the CCP's perception that state-led innovation is an essential part of redirecting the market to fulfill political objectives and subsequently strengthen CCP security. As pressure from the international community around China's practices increases, China's policymakers are looking to assert greater control over the economy, shield its companies from foreign backlash, and direct investment toward high-priority needs such as food security and healthcare. To achieve these objectives, the CCP is rolling out a framework of in-

*FYPs are economic policy blueprints that enumerate the Party's objectives and priorities during the ascribed time period. FYPs historically have centered on production targets or other numerical targets, rooted in the command economy of the Soviet Union and inherited by other Communist regimes. *Economist*, "What Is China's Five-Year Plan?" March 4, 2021.

†The CCP regards 2049 with particular importance as the year will mark the centennial of the founding of the People's Republic of China. Evelyn Cheng, "Xi at Communist Party Anniversary: China Won't Accept 'Sanctimonious Preaching' from Others," *CNBC*, July 1, 2021.

centives to reward companies that follow government guidance and punish those that stray from it.

This section begins with a discussion of CCP economic policymaking, including its growing emphasis on achieving technological self-sufficiency while it assumes further control of key industries for both state and nonstate firms. It then examines the CCP's strategies—including plans for international expansion—around three of many sectors the CCP views as crucial to China's economic future: synthetic biology, new mobility, and cloud computing. Finally, it examines the CCP's recent efforts to promote a sovereign digital currency and its reasons for doing so, which include economic as well as domestic and geopolitical motivations. The section draws from the Commission's April 2021 hearing on "An Assessment of the CCP's Economic Ambitions, Plans, and Metrics of Success," the Commission's staff and contracted research, consultations with policy experts, and open source research and analysis.

Plotting Economic Innovation to 2025

At the start of 2021, China was ahead of the world in post-pandemic recovery while also looking ahead to key CCP milestones. Foreign criticism and pushback against the CCP's policies and practices, along with growing domestic challenges, clouded the outlook for 2021 and helped to strengthen the internal push for self-sufficiency. Demographic decline, environmental degradation, income inequality, and a growing debt burden remain pressing challenges to China's economic growth and social stability while inherently testing CCP control. (For more on these challenges, see Chapter 1, Section 1, "The Chinese Communist Party's Ambitions and Challenges at Its Centennial.") Chinese policymakers formulated the 14th FYP in view of near-term difficulties and their ability to deliver on long-term guarantees of CCP economic management. While these considerations did not drive a departure from previous economic planning and tools, they did push the CCP into a deeper reassessment of China's links to the global economy. In addition to its domestic objectives for technology, the CCP wants to gain international leadership in key technologies to both promote Chinese companies abroad and benefit from controlling the path of global innovation. The 14th FYP outlines the CCP's strengthened commitment to a top-down approach and strategy for realigning China's economic relationships to insulate against disruptions from foreign policies and other external shocks.

The 14th FYP also illustrates the CCP's view that technological upgrades will solve its slowing productivity growth, a problem that has weighed on China's economy for over a decade. Loren Brandt, Noranda chair of economics at the University of Toronto, argues that China's productivity growth was once driven by an abundant supply of labor and strong performance of the nonstate sector, but it has been on the decline since 2007.[3] In testimony before the Commission, Dr. Brandt attributed the decline to increased state direction and a departure from government policies of the 1990s and 2000s that enabled the nonstate sector of the economy to flourish.[4] During that period, government policies lowered barriers to firm entry and allowed labor to move from

agriculture to industrial sectors, where workers gained skills and training. Over the last 15 years, the state's hold on capital- and skill-intensive industries tightened. Education and skills among the workforce also did not progress enough to meet the demand of new high-tech industries.[5] According to Dr. Brandt, the Chinese government's return to a top-down approach has only exacerbated the drag on productivity, but the CCP sees a top-down approach as a necessity to direct resources into technologies that can boost productivity growth.[6]

The CCP Seeks Supply Chain Security

China's decades-long drive for self-sufficiency has intensified in the wake of extensive U.S. actions to limit access to technology by problematic Chinese companies. The U.S. export control regime, for example, not only affects the flow of goods from the United States to target countries but also extends to third countries' exports of goods that contain U.S. content. In other words, U.S. controls limit the ability of third countries to send controlled technology to certain end users. Since 2018, the Department of Commerce has added nearly 250 Chinese companies and research institutes to its Entity List.[7] Ling Chen, professor of political economy at the Johns Hopkins School of Advanced International Studies, testified that for Chinese tech companies targeted by U.S. sanctions, "their success or failure was interpreted [by the Chinese government] as a matter of national survival."[8]

Weakening global demand coupled with greater global scrutiny of China's companies has prompted Chinese policymakers to focus on supply chain security. Even prior to the novel coronavirus (COVID-19) pandemic, China's government was seeking to insulate China's supply chains from all manner of shocks, such as a sudden drop in foreign demand, constraints on logistics and transportation, or foreign laws and regulations seeking to block the flow of goods and services. Recognition of these vulnerabilities has been a key driver of China's dual circulation strategy, which aims to reduce dependence on solely export-led growth, and increasing domestic consumption while increasing foreign reliance on China. (For more on dual circulation, see Chapter 1, Section 1, "The Chinese Communist Party's Ambitions and Challenges at Its Centennial.")

For the central government, securing supply chains means not only reducing vulnerabilities with respect to foreign sources but also increasing China's role in higher-value supply chains. Matt Pottinger, distinguished visiting fellow at the Hoover Institution and former deputy national security adviser, called China's approach "offensive decoupling," or a "one-way decoupling," because it seeks to increase global dependencies on Chinese products while also onshoring production in key sectors.[9] In testimony before the Commission, Mr. Pottinger also defined offensive decoupling as the CCP seeking to decouple on its own terms and use economic leverage for political goals.[10] These actions and the underlying strategy demonstrate what the CCP views as a broad definition of security and its heightened sense of vulnerability.

The 14th Five-Year Plan Places Self-Sufficiency at the Core of China's Development

The 14th FYP comes at a critical time as Chinese policymakers seek to respond to long-standing domestic economic challenges, manage post-COVID-19 recovery, and mitigate mounting international criticism. Released in the same year as the CCP's centennial anniversary, the 14th FYP reflects the CCP's desire to show that its leadership is essential for sustaining a robust economy while concealing or shoring up many negative spillovers of the CCP's approach. One such spillover effect is growing income inequality. Notably, the 14th FYP looks far beyond 2025 to 2035, which is when the country's policymakers envision that China will effectively modernize in key areas and overcome various forms of economic inequality. The 2021–2025 period is also viewed as the beginning of the next great phase of development toward 2049, which will mark the centennial of the founding of the People's Republic of China.[11] According to General Secretary Xi, China has achieved the 13th FYP's goal of a "moderately prosperous society."[12] The national vision for the 14th FYP is to become a "modern socialist country," a concept that General Secretary Xi outlined in 2017 to include expansion of the middle class and reduction of income inequality.[13] (For more on this concept, see Chapter 1, Section 1, "The Chinese Communist Party's Ambitions and Challenges at Its Centennial.")

The policy goals of the 14th FYP remain similar to past plans in terms of core content and direction, but the plan demonstrates a distinct shift in messaging and tone. Income growth is not presented as an underlying guarantee of the plan, while overall economic growth serves as a means to maintaining Party control and stability over the long term. Chinese policymakers are shifting their narrative emphasis from discrete numerical targets to focus on what they call "high-quality growth." Chinese officials use this term to acknowledge some of the negative effects of a growth-at-all-costs approach, such as environmental degradation, poor healthcare, and income inequality. For the CCP, high-quality growth is an essential component of ensuring social stability. The CCP must assure Chinese citizens that there are still opportunities in the economy and that the Chinese people can rely on the CCP for a robust social safety net. In the past, Chinese policymakers frequently mentioned the need for quality-of-life improvements, but the 14th FYP is the first plan to focus on qualitative rather than quantitative targets, according to Hu Zucai, deputy director of China's National Development and Reform Commission.[14] Accordingly, the 14th FYP is also the first plan that does not incorporate a gross domestic product (GDP) growth target for the concluding year of the plan.

Instead of precise numerical targets, the 14th FYP is more focused than previous plans on qualitative assessments to fulfill basic needs of childcare and education, healthcare, eldercare, and employment.[15] Chinese state media have noted that the qualitative growth approach is appropriate for current uncertainty and would "help China respond to various risks and challenges in a more active and flexible way."[16] This emphasis on quality of life provides Chinese government agencies a broad runway to complete a smaller set of goals and performance indicators. In contrast to

previous plans, the 14th FYP also introduces new metrics of economic success such as food security and energy security, which have gained importance in the face of an increasingly dire set of demographic and environmental circumstances. Chinese planners hope innovation in areas like agricultural biotechnology and renewable energies will ensure that key quality-of-life goals can be achieved through enhancing China's domestic capabilities and greater self-sufficiency.

The specific areas of emphasis identified for innovation in the 14th FYP are largely consistent with the Made in China 2025 policy, first introduced in 2015 (see Table 1). Chinese policymakers continue to prioritize advancements in the same sectors, including AI, new materials, advanced manufacturing, aerospace, and agricultural machinery. While featured in previous plans, the 14th FYP emphasizes the linkage between innovation, development, and security to intentionally de-emphasize growth objectives. Innovation is viewed as an enabler for many other sectors that will support Chinese growth and help the government mitigate domestic and international challenges. For instance, innovations like AI and synthetic biology will improve healthcare while smart manufacturing will maximize value-added productivity gains.

Table 1: China's Key Technology and Sectoral Targets Comparison

Made in China 2025	**14th FYP**
Next Generation IT Integrated Circuits	Quantum Information Integrated Circuits Beidou* Navigation Satellite System
High-End Computerized Machines and Robots	Major Technical Equipment Smart Manufacturing and Robotics
Space and Aviation	Space and Aviation Airplane Engines and Gas Turbines
Maritime Equipment and High-Tech Ships	Ships and Maritime Equipment
Advanced Railway Transportation Equipment	Advanced Railway Transportation Equipment
New Energy and Energy-Saving Vehicles	New Energy Vehicles and Smart (Connected) Vehicles
Energy Equipment	Advanced Energy Equipment
Agricultural Machines	Agricultural Machinery and Equipment
New Materials	High-End New Materials
Biopharmaceuticals and High-Tech Medical Devices	High-End Medical Equipment and Innovative Drugs

Source: Simon Rabinovitch (@s_rabinovitch), "'Made in China 2025' is dead. Long live 'Made in China 2025'! China's new Five-Year Plan is not nearly as detailed as its controversial MiC 2025 plan, but it targets all the same sectors & technologies, plus a few more." Twitter, March 11, 2021, 10:26 p.m. *https://twitter.com/S_Rabinovitch/status/1370214528571514884*.

*Beidou is China's global navigation satellite system and has achieved global coverage as of 2020 with 35 satellites worldwide. Beidou is operated by the China National Space Administration. GPS, "Other Global Navigation Satellite Systems."

The "Ten-Year Sprint" to Ensure China's Global Competitiveness

As Chinese policymakers seek to transform China into a "modern socialist country," they believe they have a relatively narrow window to do so. Key CCP plans to address the structural challenges in China's economy, which target completion by 2030 and 2035, indicate an urgency in the Party's timeline. Predictions that the country's population will peak between 2025 and 2030 have fueled the urgency to address a host of problems that will come with demographic decline, including a smaller workforce, a more elderly population, and increased strain on government budgets and China's social safety net.[17] Jude Blanchette, Freeman chair at the Center for Strategic and International Studies, noted in testimony before the Commission that because these challenges "threaten to derail China's development path and global ambitions, it's clear that Beijing is engaged in a decade-long sprint, not a hundred-year marathon."[18] In other words, as Michael Beckley and Hal Brands of the American Enterprise Institute argue in *Foreign Affairs*, this indicates that U.S. competition with China could be "short and sharp."[19]

Chinese policymakers have long acknowledged weaknesses in the country's science and technology systems, particularly in basic research and development (R&D) and the struggle to draw in talent.[20] These deficiencies will become even more crucial not just in the global tech race, but also in the CCP's race against economic slowdown and demographic decline. The CCP views innovation, development, and security as intrinsically linked and believes development of science and technology will answer its domestic and foreign policy problems. Chinese planners appear confident that they are on track to achieve the necessary talent and tech breakthroughs. At the same time, their approach recognizes challenges to the research environment and its management by various government and nonstate actors. The 14th FYP establishes a ten-year action plan to strengthen basic research, commits to changing regulations to support a more dynamic system of R&D, and outlines steps to grow talent. At the same time, policymakers will need to make significant improvements in the education system likely beyond what the 14th FYP prescribes to increase workforce opportunities in an era that values science and technology skills. Inadequate rural education remains a critical obstacle to the future of Chinese employment as China's 900 million rural residents often lack education beyond a high school level.[21] With only 15.5 percent of China's population college-educated as of China's 2020 census, shifting employment from low-wage labor toward knowledge-intensive innovation and services will be a challenging transition.[22]

CCP Control of China's Nonstate Sector Is Increasing

Under General Secretary Xi, the CCP has increased its control of China's economy in ways that have further enhanced the linkages between state and nonstate firms. In addition to promoting state-owned enterprises (SOEs), the CCP has also embraced hybrid forms of financing that allow it to direct capital toward, and increase influence in, nonstate enterprises. This approach is typified by the CCP's use of new tools to extend its reach, including government guidance funds, which are state-nonstate investment vehicles that

seek to raise capital for firms operating in strategic and emerging industries such as AI. According to a March 2021 report by the Center for Security and Emerging Technology at Georgetown University, as of 2020 the Chinese government had set up 1,741 government guidance funds, with a total of more than $740 billion (RMB 4.76 trillion) raised.*[23]

As Chinese and foreign economists have noted, the CCP's oversight of China's economy—and the integration of state and nonstate firms in an economic policymaking ecosystem—brings certain advantages to China's economic development. According to Mr. Blanchette, "The power of China's state capitalist system stems from the synergies created through strategic alliances, cross shareholdings, frequent personnel rotations; and, increasingly, complex vertical integration."[24] This is exemplified in the case of COSCO Shipping Group, an SOE that in 2017 raised more than $1 billion from other SOEs to fund its purchase of 20 new ships.[25] As Mr. Blanchette noted, "Most of COSCO's foreign competitors do not possess the ability to raise capital via government-orchestrated equity sales."[26]

For all its ostensible advantages, China's state-led model imposes significant costs on China's economic growth as well. For instance, the Center for Security and Emerging Technology study on government guidance funds concluded that the funds had several important shortcomings, including misallocation of funds, an overabundance of funds that leads to redundant and inefficient investment, a reliance on "inexperienced, poorly incentivized" bureaucrats, and crowding out of more efficient nonstate-sector investment.[27] The report concludes that many of these problems "are not merely 'growing pains,' but are rooted in basic issues of institutional capacity and contradictions in the model—between CCP aims and the profit motive, and between national visions of technological development and local, shorter-term economic development interests."[28] Nevertheless, CCP policymakers are willing to accept suboptimal economic outcomes if it ensures achievement of political objectives. As Mr. Blanchette wrote, "Such weaknesses are not lost on China's industrial planners, who instead appear to have adopted a 'venture capitalist' approach that implicitly understands most investment 'bets' won't be winners. The goal, then, is to place sufficient bets to ensure enough productive, profitable, or strategic outcomes."[29] (For further discussion on government guidance funds, see Chapter 2, Section 3, "The Chinese Government's Evolving Control of the Nonstate Sector.")

China's Strategy for Emerging Industries

As the CCP sets its sights on the horizon for technological upgrading, it is also seeking to ensure Chinese global leadership in key fields. The 14th FYP enumerates ambitions across a range of emerging technologies, most of which have been previously singled out for government support.

This section examines the Chinese government's promotion of synthetic biology, new mobility, and cloud computing—each itself a constellation of related technologies foundational to achieving breakthroughs outlined in the 14th FYP. Synthetic biology has the

*Unless noted otherwise, this section uses the following exchange rate throughout: $1 = RMB 6.43.

potential to transform nearly every sector of China's economy, including some of the sectors Chinese policymakers view as the most important, such as agriculture, energy, and medicine. While many of its applications remain in development, synthetic biology also shows great promise in addressing important quality-of-life issues the CCP views as underpinning its own legitimacy. Developing new mobility—an umbrella term that captures everything from ride-hailing services to autonomous vehicles (AVs)—is a strategic imperative for the CCP as it seeks to both lower China's carbon emissions and improve transportation systems for an increasingly urban and aging population. New mobility is integral to China's smart cities ambitions and stands to enhance the CCP's digital surveillance methods, which has implications well beyond China's borders. Chinese leaders have long prioritized cloud computing, both as a critical channel of information flows and for its role in enhancing data collection, transfer, and storage in practically all other sectors due to increased integration of digital services across the economy. Cloud computing enables the mass collection and transfer of genomic data, powers machine learning in transportation infrastructure, and undergirds digital financial payments and recordkeeping.

Advancement in each of these technologies could fulfill several strategic objectives. Development of these technologies may translate into immense economic gains as Chinese firms realize their commercial value. The CCP also hopes that these technologies can help alleviate many of the social and environmental problems currently facing the Chinese population. Finally, the CCP believes leadership in these fields is a valuable geopolitical tool that affords the Party the ability to set international standards favorable to its own interests.* Chinese government policies and tactics to achieve these goals harbor potentially significant implications for the stability of U.S. employment in key sectors, national security, and global competitiveness.

The CCP Views Synthetic Biology as Key to Solving Economic and Livelihood Problems

The CCP believes synthetic biology can help address many of China's most pressing issues, from healthcare needs of an aging population to food supply challenges created by climate change.[30] Synthetic biology (also known as engineering biology) is a type of biotechnology focused on designing or redesigning biologically based parts, devices, and systems for useful purposes.† According to the U.S. National Academy of Sciences, there is no precise difference between synthetic biology and other types of biotechnology. Broadly speaking, however, synthetic biology is characterized by the use of approaches common to engineering disciplines, including computational modeling and the construction of prototypes based on the computational models.[31] Scientists generally understand the term "synthetic biology" to comprise three technologies: (1) gene sequencing (including the ability to "read" the human genome), (2) gene

*For more on the CCP's attempts to expand China's influence in international standards-setting organizations, see U.S.-China Economic and Security Review Commission, Chapter 1, Section 2, "The China Model: Return of the Middle Kingdom," in *2020 Annual Report to Congress*, December 2020, 80–135.

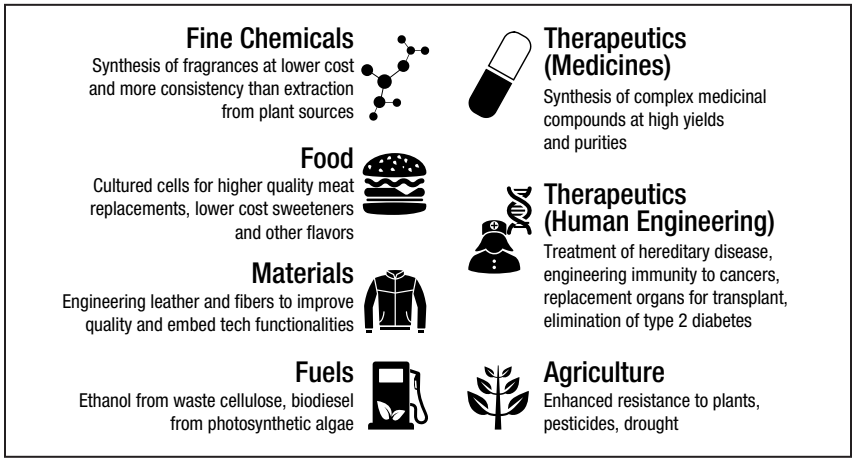
†For more on China's ambitions in biotechnology, see U.S.-China Economic and Security Review Commission, Chapter 2, Section 3, "U.S.-China Links in Healthcare and Biotechnology," in *2020 Annual Report to Congress*, December 2020, 293–327.

editing (i.e., changing existing DNA), and (3) gene synthesis (i.e., creating DNA and inserting it into an existing genetic sequence).[32]

Synthetic biology is a rapidly growing field with the potential to revolutionize many different industries, including food, agriculture, medicine, and energy (see Figure 1). Ginkgo Bioworks, one of the world's largest biotechnology firms, has predicted synthetic biology will one day be able to produce "virtually any physical good."[33] One immediate application of synthetic biology has been to address the COVID-19 pandemic through the rapid development of testing kits and vaccines.[34]

While advances in synthetic biology will yield benefits to global consumers, the greatest advantage will accrue to the countries that claim leadership in the field, ranging from economic gains such as greater employment opportunities to the ability to play a leading role in the global governance of synthetic biology.[35] Leadership in synthetic biology also carries significant national security implications, including the development of new materials with military applications and the possible creation of more virulent bioweapons.[36]

Figure 1: Applications of Synthetic Biology



Source: Adapted from Tara O'Toole, "Synthetic Biology and National Security: Risks and Opportunities," *Center for Strategic and International Studies*, April 14, 2020.

U.S. scientists agree that while the United States remains the global leader in synthetic biology, its advantage is declining due to China's rapid advances in the field.[37] Jason Kelly, CEO of Gingko Bioworks, testified before the Commission that China's national champion, BGI, the world's largest genomics company, has already reached near-parity with U.S. firms in gene sequencing.*[38] According to Dr. Kelly, China has not yet reached parity with the United States on gene editing and gene synthesis, but it is gaining ground.[39] Dr. Kelly noted that maintaining U.S. leadership in bio-

*BGI was founded in 1999 as Beijing Genomics Institute to contribute to the Human Genome Project, an international scientific research project that successfully mapped all human genes. Mark Kazmierczak et al., "China's Biotechnology Development: The Role of U.S. and Other Foreign Engagement," *Gryphon Scientific and Rhodium Group* (prepared for the U.S.-China Economic and Security Review Commission), February 14, 2019, 25; Oak Ridge National Laboratory, "History of the Human Genome Project."

technology will require government support, comparing it to the U.S. government's support of the defense industry in the 1950s.[40] China's advances have been driven by generous government support for synthetic biology research and significant efforts to obtain research and data from foreign countries, including the United States, sometimes illicitly.

China's Strategy for Synthetic Biology

In recognition of the transformative potential of synthetic biology and the importance of leadership in the field, the 14th FYP has listed biotechnology, including synthetic biology, as one of seven fields in science and technology where the CCP will focus resources and strategic planning.[41] Although detailed data on Chinese government spending on biotechnology are unavailable, according to some estimates, China's central, provincial, and local governments have collectively invested over $100 billion in life sciences R&D.[42] This government support includes the establishment of synthetic biology institutes in Beijing and Tianjin.[43]

Government backing has also been essential to some of China's top synthetic biology companies, including BGI, which received substantial government regulatory support soon after it was founded in 1999 and continues to receive subsidies.[44] In 2010, BGI received $1.5 billion in funding from China Development Bank, a state bank, to expand its operations.[45] Some of the funding was used to purchase gene-sequencing machines from Illumina, a U.S. company, several years before BGI began producing its own gene-sequencing equipment.[46]

China's International Expansion in Synthetic Biology

As part of China's efforts to become a global leader in synthetic biology, Chinese companies and researchers have sought to gain access to foreign expertise. In some cases, Chinese companies' purchases of foreign companies have driven significant breakthroughs in China's own capabilities in synthetic biology. In 2013, BGI purchased Complete Genomics, a U.S. gene-sequencing company.[47] In 2020, Complete Genomics announced it would be able to sequence a human genome for $100, compared to $600 for most of its competitors.[48] The Chinese government has also supported investment in non-U.S. firms. In 2017, ChemChina, a state-owned firm, purchased Syngenta, a Swiss agrichemical company, for $43 billion, the largest-ever Chinese takeover of a foreign company.[49] In buying Syngenta, ChemChina acquired not only valuable seedstocks but also research applications for CRISPR, a highly precise and efficient gene-editing technology used in synthetic biology.*[50]

Collection of Genomic Data Key to Global Synthetic Biology Leadership

Genomic data, whether it comes from humans, other animals, or organisms such as plants, provide crucial inputs for advances in syn-

*Both BGI's purchase of Complete Genomics and ChemChina's purchase of Syngenta received clearance from the Committee on Foreign Investment in the United States. Jacob Bunge, Brian Spegele, and William Mauldin, "Powerful U.S. Panel Clears Chinese Takeover of Syngenta," *Wall Street Journal*, August 23, 2016; *Genome Web*, "Complete Genomics, BGI Get Clearance from U.S. Committee; Tender Offer Extended," December 31, 2012.

thetic biology. For instance, using genomic data from SARS-CoV-2, the virus that causes COVID-19, scientists were able to develop prototype COVID-19 vaccines for human testing in less than a year.*[51] Previously, the fastest a vaccine had been approved for human use was the mumps vaccine in the 1960s, which took four years.[52] Recognizing the importance of genomic data and its role in synthetic biology leadership, the CCP has set ambitious goals to collect and catalogue genomic data both within China and from other countries.

Human Genomic Data

The Chinese government has long prioritized the collection of human genomic data. The CCP has collected the human genomic data of millions of its citizens: a 2020 report by the Australian Strategic Policy Institute estimated that the Chinese government possesses genomic data of up to 140 million people, the largest such dataset in the world.[53] The collection of genomic data is important for research and development of new medical treatments, but it has also been used to further the CCP's efforts to monitor its citizens and persecute ethnic minorities (see textbox "DNA Collection Enables CCP Monitoring of Uyghurs and Other Ethnic Minorities").

In addition to domestic collection efforts, the CCP has also collected human genomic data abroad. The genomic diversity from foreign samples could enable research discoveries and enhances the likelihood of commercial breakthroughs from such research.[54] Chinese entities have gained potential access to U.S. healthcare data through investment in U.S. firms such as genetic testing company 23andMe, sales of equipment and gene sequencing services, and partnerships with U.S. universities and hospitals.[55] In many cases, Chinese regulations prevent foreign researchers from gaining reciprocal access to Chinese data.[56] Chinese state-sponsored groups have also targeted U.S. healthcare data through hacking U.S. healthcare providers and businesses.†

The international sale of certain medical products manufactured by Chinese firms has provided the Chinese government potential access to genomic data from populations around the world. A July 2021 Reuters report found that BGI's prenatal tests, which are sold in at least 52 countries (though not the United States), were developed in coordination with the People's Liberation Army.[57] The prenatal tests collect a wide range of information, including genetic code, location of the tests, and medical history of the mother. The Reuters investigation found that genetic information of at least 500 women, including women outside of China, was stored in the National GeneBank, a government-supported project administered by BGI to research hundreds of millions of genetic samples of humans, animals, plants, and microorganisms.‡[58]

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*The official name of the novel coronavirus responsible for the pandemic is "severe acute respiratory syndrome coronavirus 2," which is abbreviated SARS-CoV-2. COVID-19 is the name of the disease caused by the SARS-CoV-2 virus. World Health Organization, "Naming the Coronavirus Disease (COVID-19) and the Virus That Causes It," 2020.

†For more on the CCP's efforts to gain access to foreign healthcare data, see U.S.-China Economic and Security Review Commission, Chapter 2, Section 3, "U.S.-China Links in Healthcare and Biotechnology," in *2020 Annual Report to Congress*, December 2020; U.S. Cybersecurity & Infrastructure Security Agency, "China Cyber Threat Overview and Advisories."

‡BGI issued a statement disputing the Reuters report, including the assertion that the prenatal tests were developed with the People's Liberation Army. In the statement, BGI also said it "has never been asked to provide, nor has it provided data from its [prenatal] test to Chinese

The use of Chinese test kits by U.S. citizens presents the possibility for U.S. patient data to be collected for use by the Chinese government. In March 2021, Amazon announced it was partnering with BGI to use a modified version of BGI COVID-19 test kits, initially for at-home testing of Amazon employees.[59] The company's announcement came weeks after the National Security Commission on Artificial Intelligence noted in its report that BGI's COVID-19 testing kits "potentially provide access to large international genetic data sets" and warned that "BGI may be serving, wittingly or unwittingly, as a global collection mechanism for Chinese government genetic databases, providing China with greater raw numbers and diversity of human genome samples as well as access to sensitive personal information about key individuals around the world."[60]

DNA Collection Enables CCP Monitoring of Uyghurs and Other Ethnic Minorities

The CCP's earliest efforts in mass collection of genomic data focused on ethnic minority groups in Tibet and Xinjiang, where scientists gathered tens of millions of samples during what the Chinese government said were free annual physicals.*[61] Along with DNA samples, Chinese authorities collected other forms of biometric data, including photographs, voice recordings, fingerprints, and iris scans, to be stored in police databases.[62] The biometric data collected from these populations have augmented the use of high-tech surveillance methods to monitor ethnic minorities, including the predominantly Muslim Uyghur population of Xinjiang. A 2019 *New York Times* report found that Chinese police have used facial recognition technology to determine whether residents of some cities were Uyghurs.[63]

U.S. companies in the past have come under criticism for selling DNA and surveillance equipment to Chinese authorities.[64] In October 2019, the Department of Commerce placed 28 organizations, including the Xinjiang Public Security Bureau and affiliated entities, on its Entity List due to their involvement in "China's campaign of repression, mass arbitrary detention, and high-technology surveillance against Uyghurs, Kazakhs, and other Muslim minority groups in [Xinjiang]," actions the U.S. government has since deemed to constitute genocide.[65] U.S. firms are prohibited from conducting business with organizations on the Entity List without first receiving a government license. In June 2021, however, the *New York Times* reported that Xinjiang police departments continued to purchase DNA equipment produced by U.S. companies by obtaining it through Chinese intermediaries not on the Entity List.[66]

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authorities for national security or national defense security purposes." BGI, "BGI Statement in Response to Reuters Report," July 8, 2021.

*According to an interview with one Uyghur man living in Xinjiang, the physical involved recording his voice and taking his fingerprints but did not involve checking his heart or kidneys. Sui-Lee Wee, "China Uses DNA to Track Its People, with the Help of American Expertise," *New York Times*, February 21, 2019.

Nonhuman Genomic Data

China's genomic collection also extends to nonhuman genetic data, which Dr. Kelly described as "the raw material of the bioeconomy" in his testimony before the Commission.[67] While China has historically had high levels of biodiversity, environmental degradation has caused the loss of many species.[68] China has sought to collect genomic data from many other countries through various channels. In September 2019, BGI announced a joint venture with SpaceTime Ventures in Brazil, which included plans to establish a large-scale R&D center studying tropical plant genomics along with associated sequencing and bioinformatics infrastructure.[69] BGI has also entered into collaborations with institutions in Ethiopia and South Africa.[70]

The COVID-19 pandemic has provided China with further opportunities to collect nonhuman genomic data. BGI has built COVID-19 testing laboratories and sold test kits that collect genomic data on the virus that causes COVID-19 around the world. By August 2020, BGI sold more than 35 million COVID-19 test kits to 180 countries, including the United States, and had established 58 COVID-19 testing laboratories in 18 countries.[71] BGI's establishment of these labs provides China with a network of laboratories to collect and sequence genomic data from around the world.[72]

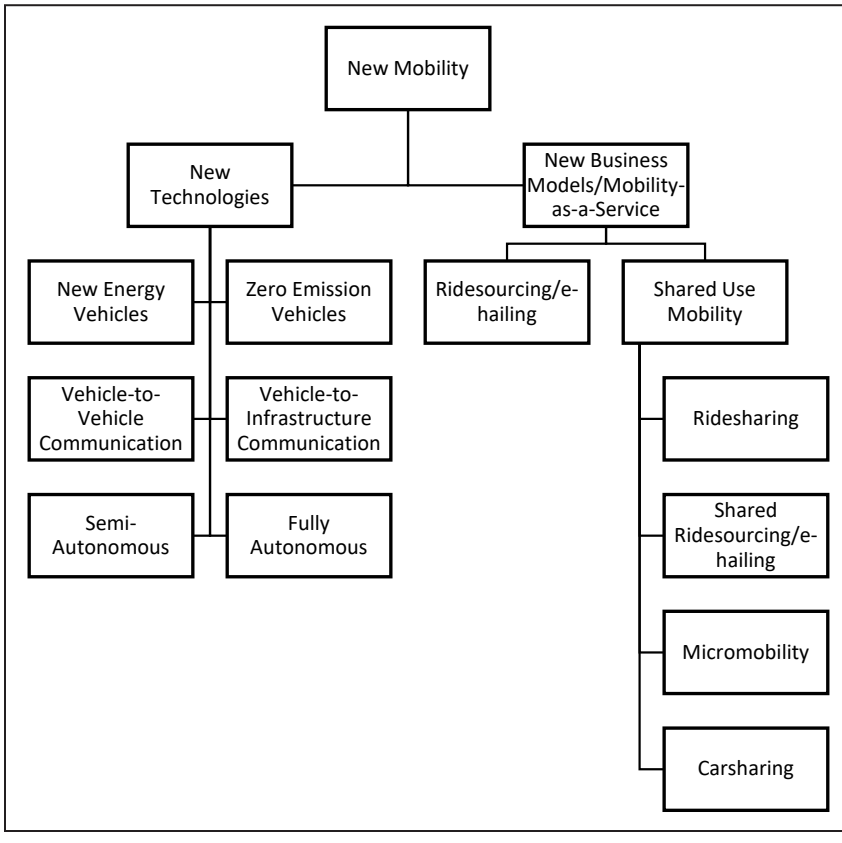
Many of the world's most biodiverse countries are unaware of the potential value of nonhuman genomic data.[73] Moreover, global standards for collecting, protecting, sharing, and monetizing genomic data remain largely undeveloped.* A country that collects more genomic data will have a distinct advantage not only in being able to use the gathered data for commercial gains but also in being able to set international standards for sharing such data.[74] According to Dr. Kelly, neither the United States nor China currently leads in the collection of nonhuman genomic data, but China has the opportunity to collect massive amounts of nonhuman genomic data from other countries on highly favorable terms.[75] China's leadership could lead to a more closed system for nonhuman genomic data sharing, in contrast with the United States' role in establishing open ecosystems that have set international standards for technologies such as mobile phones, personal computers, and the internet.[76]

New Mobility Drives Chinese Sustainability and Global Competition

The term "new mobility" refers to two broad categories of innovation in transportation: (1) new technologies, such as NEVs and connected or autonomous vehicles; and (2) new business models or social trends, including ride-hailing apps or "mobility-as-a-service" (MaaS), which integrates different modes of travel in one platform (see Figure 2).[77] MaaS offerings can include any combination of public transit, individual automobiles, bikes, or scooters, and include companies like ride-sharing giant Uber or the bike and scooter-sharing company Lime.

*The Convention on Biological Diversity, a 1993 international treaty, addresses some aspects of the international exchange of biological materials. China is a party to the Convention on Biological Diversity, while the United States is not. Convention on Biological Diversity, "List of Parties."

Figure 2: New Mobility Subsectors



Source: Adapted from Peter Slowik and Fanta Kamakaté, "New Mobility: Today's Technology and Policy Landscape," *International Council on Clean Transportation*, July 2017, 2; Dana Yanocha and Mackenzie Allan, "Maximizing Micromobility," *Institute for Transportation & Development Policy*, July 2021, 5–7.

Autonomous and connected vehicles are poised to be the most disruptive new mobility technologies. Drawing a distinction between the two sets of technologies, Joanna Moody, then research program manager at the Massachusetts Institute of Technology Energy Initiative Mobility Systems Center, noted that an AV can "make its own driving decisions independently," whereas "connected vehicles exchange driving information with other vehicles (potentially both automated and nonautomated vehicles) and/or transportation infrastructure."[78] Connected vehicles may also connect with passengers' mobile communication devices.[79]

Where internal combustion engines powered growth and innovation in the 20th century, new mobility has broad implications for the digital economy in the 21st century. For China and many other countries, new mobility will help reduce pollution, accelerate the development of smart cities, and promote better accessibility of transportation infrastructure. For the United States, new mobility will also transform the automotive industry, which remains one of the

largest U.S. employers. According to the U.S. Bureau of Labor Statistics, as of August the automotive industry supported 923,300 manufacturing jobs and 3.2 million jobs in automotive retail in 2021.[80] In 2020, NEV production employed more than 261,000 people in the United States.[81] Management consulting firm McKinsey estimates that global revenues from AV commercial fleets and personal transportation in urban areas could reach $1.6 trillion a year by 2030—more than twice the combined 2017 revenues of Ford, General Motors, Toyota, and Volkswagen.[82] Meanwhile, the MaaS market is predicted to reach $106.8 billion by 2030, with expected annual growth of 20 percent from the current market valuation of $60 billion.[83]

China's Strategy for New Mobility

After decades of investment, China's government has achieved only limited success in the production of internal combustion engine vehicles, but it is determined to achieve leadership in the next generation of mobility technologies. A 2020 China State Information Office white paper, *Sustainable Development of Transport in China*, described transportation as "a basic, leading, and strategic sector of the economy underpinning sustainable development."[84] China's government has set a goal of establishing a "modern comprehensive transport system" by 2035 and emphasized "raising the quality of the transport industry through digital, internet-based, intelligent, and green technologies."[85] The white paper also highlighted China's move "from follower to leader" in transport technology and referenced other international ambitions, including "promoting reform of global transport governance."[86] While China's central government sets broad policy goals for transportation, cities have played an increasingly important role in setting individualized transportation policies to meet these goals.[87] Local government involvement has been key to expanding the new mobility ecosystem with companies able to refine their business models and product testing based on local conditions.

Although China's government has recently improved the legal framework for foreign automotive companies, such measures have done little to counteract obstacles facing U.S. automakers, such as policies discouraging the purchase of internal combustion engine vehicles and preferential treatment of domestic firms. Despite U.S. automakers' longstanding presence in China's auto market, U.S. firms have struggled to gain a bigger market share there. In 2018, China's National Development and Reform Commission announced it would phase out regulations that limited foreign investment and ownership over automobile companies along with requirements for foreign automobile companies to form joint ventures with Chinese companies.[88] Companies manufacturing NEVs were the first type of car companies to be exempt from this requirement, beginning in 2018.[89] A 2019 Office of the U.S. Trade Representative report on China's WTO compliance nonetheless found U.S. firms face other disadvantages in China's market, in part due to other policies "apparently designed to promote the development of a Chinese NEV industry at the expense of foreign enterprises."[90] These policies include government subsidies in connection with the purchase of Chi-

nese—but not foreign—NEVs.[91] Between 2018 and 2020, U.S. auto imports were also subject to Chinese retaliatory tariffs in response to U.S. Section 301 tariffs.[92] This dynamic depressed U.S. car sales in China over this period, though China lifted its tariffs following the finalization of the U.S.-China Phase One agreement in January 2020.[93] Many other administrative barriers remain with complex networks of regulations and standards unique to China that are generally easier for local companies to navigate.

Autonomous and Connected Vehicles

For China's government, autonomous and connected vehicles are a critical part of advancing a digital infrastructure strategy. Such vehicles not only make it possible to overcome labor shortages for an array of positions like delivery drivers but also hold the potential to increase road safety.[94] In 2020, the central government proposed that half of all new cars sold would be at least semi-autonomous by 2025.[95] Beginning in 2017, cities such as Beijing, Shanghai, and Guangzhou have developed policies to allow AV testing, and many local governments have provided subsidies and favorable policies to companies working on AVs.[96] While most of the automakers testing on Chinese roads are domestic companies, General Motors' subsidiary in China, Cruise, has been testing some self-driving functions, though not fully autonomous systems, since 2017.[97] Central government guidance in January 2021 also encouraged local governments to open up more testing and permits as it aims to speed up deployment of AVs and catch up with U.S. AV testing efforts.[98] Other foreign companies like Audi, BMW, Daimler, and Volkswagen have also been able to test autonomous driving in Chinese cities since 2018.[99] Honda, Toyota, and Volvo have partnered with Chinese companies like Pony.ai and AutoX to provide vehicles that rely on Chinese autonomous driving systems.[100]

At the same time, Chinese regulators are seeking to capitalize on the data-gathering potential of AVs and are moving forward with new rules to address data usage, which may impact foreign firms. Between March and May 2021, the Chinese government restricted military and key SOE personnel from using Tesla cars and moved to prohibit parking Tesla cars near government compounds due to national security concerns about vehicle sensors and cameras.[101] In May 2021, the Cyberspace Administration of China released draft rules for the security of car data, which aim to protect consumer information along with controlling "important data" that may be sensitive to national security.[102] The "important data" subject to restriction in the draft includes surveying and mapping data with greater accuracy than public maps; it also includes a catch-all clause for "other data that may affect national security and public interests."[103] The draft rules mandate localization of important data as well as specific approval and certification processes to transfer the data overseas. The broad scope of important data increases the possibility of arbitrary restrictions that may limit the effectiveness of foreign AV systems and also introduces an additional administrative burden on companies seeking operations in China. In May 2021, Tesla announced it was building a data center in China to assuage concerns about security.[104]

Mobility-as-a-Service and Shared Mobility

MaaS and shared mobility encompass a broad range of services that the Chinese government has at times encouraged and occasionally struggled with as these services have demonstrated applicability to key social problems. Central government ambitions for tech champions along with idiosyncrasies of local governments and their transportation needs have inspired the growth of multinational giants like Didi Chuxing ("Didi") along with less successful bike-sharing companies like Ofo and Mobike.[105]

Didi, China's largest ride-hailing company, was established in 2012 and began as a ride-hailing app to better connect taxi drivers with customers. Over time, the company has expanded to include not only established taxis but also a more Uber-like model of private carsharing, bikesharing, car rentals, and deliveries for a broad network of transportation services on one app. Didi has focused on sharing datasets and working with local governments to reduce traffic and improve transportation infrastructure.[106] Didi also provides increasingly localized services in some cities, including the ability to book public transit rides on the platform.[107] In 2020, Didi began to focus on addressing accessibility for consumers with disabilities, which is currently an underserved customer base that will only continue to grow with China's aging population.[108]

New Energy Vehicles and Zero Emissions Transportation

The Chinese government promotes NEV development through preferential treatment and subsidization of domestic NEV companies, demonstrating the government's emphasis on NEV promotion as both an industrial policy and an environmental policy. For Chinese policymakers, domestic production of NEVs solves several problems, including reliance on foreign technology, dependence on oil imports, and air pollution caused by internal combustion engine vehicles. Half of all electric cars in the world are currently in China, as well as 90 percent of electric buses and trucks.[109] China's growth in this industry has depended on heavy government subsidies. According to estimates by the Center for Strategic and International Studies, total government support for the NEV sector amounted to $21 billion (RMB 134.9 billion) in 2019, equivalent to 30.7 percent of total NEV sales.[110] In November 2020, China's State Council estimated NEV sales would account for 20 percent of all new car sales by 2025, up from 5 percent today.[111]

China's strategy to build up its NEV sector consists not just of constructing cars but also, crucially, manufacturing energy storage such as NEV batteries. As Dr. Moody wrote, "While much of the critical research and development that created the lithium-ion battery took place in the U.S., China's bullish investments in the commercialization of battery production and electric vehicle manufacturing have given it a clear edge."[112] China controls over 70 percent of the global NEV battery supply, a clear advantage as the country increases its proportion of NEV passenger and commercial vehicles.[113] Since batteries are the most important and often most expensive component of NEVs, Chinese control of critical minerals stands to have a significant effect on U.S. and other global NEV manufacturers.

Critically, Chinese companies control not only key nodes of battery production but also access to and processing of mineral inputs that go into production of batteries. NEV batteries rely on a number of minerals like graphite, cobalt, lithium, and nickel.[114] In 2019, China held nearly 60 percent of the world's graphite stock and was responsible for processing 80 percent of the world's cobalt.[115] New nickel production innovations in March 2021 were slated to boost China's share of processed nickel and sustain its consumption of over half the world's nickel.[116] China's stronghold over the NEV battery supply chain has historically been driven by Chinese companies seeking to capitalize on the government's NEV promotion, but those company motivations are increasingly converging with government interests in securing minerals. Strategic investments in the Democratic Republic of the Congo have allowed Chinese companies a steady flow of cobalt, though it is plagued by a legacy of child labor and calls to classify it as a conflict mineral.*[117] Manganese is emerging as a potential replacement for cobalt and is more widely available around the world, though China is the primary refiner.[118] At least 49 Chinese companies, almost all SOEs, have joined the China National Manganese Industry Technology Committee, which the *Wall Street Journal* described as a Chinese state-backed cartel.[119] Pini Althaus, CEO of USA Rare Earth, estimated that it would take the United States 20 to 30 years to catch up to China's progress in NEV battery supplies.[120]

The Chinese government's efforts to build a domestic NEV industry are most visible in China's critical hold on the NEV battery supply chain. China's dominance in both mining and refining key minerals for NEV batteries positions it as central to the overall NEV supply chain. Even if European and U.S. NEVs are competitive against Chinese NEVs, their manufacturers are nonetheless reliant on a broad set of Chinese SOEs to access and build the key component of their products. China's Contemporary Amperex Technology Company (CATL) currently makes up 31.2 percent of global market share for NEV batteries, edging out South Korean competitor LG Energy Solutions for the ranking of top battery supplier.[121] BYD, a Chinese company that also has a NEV automobile division, grew 381.9 percent year-on-year in March 2021, taking 8.9 percent of global market share.[122] In a demonstration of dependency on Chinese sources for NEV batteries, Reuters reported in June 2021 that Apple approached CATL and BYD to establish U.S. manufacturing sites that would support Apple's planned rollout for an electric vehicle.[123]

New Energy Vehicle Commercial and Rail Transportation

As Chinese policymakers emphasize ground transportation for goods as part of the dual circulation strategy, autonomous commercial vehicles and rail will be increasingly important in China. Autonomous commercial transportation solutions have been some

*Conflict minerals refer to several categories of raw minerals and their derivatives that are mined from areas subject to extreme violence where the harvesting of such materials may violate human rights. Under U.S. law, there are specifically defined "conflict minerals" under the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2012 that require disclosure and due diligence from companies whose supply chains may rely on conflict minerals. Crowe, "Conflict Minerals."

of the earliest deployed around the world. In China, trucks were the first autonomous vehicles to operate regularly for commercial purposes.[124] Autonomous commercial fleets are increasingly favored for greater fuel efficiency and safety along with likely reductions in traffic congestion.[125] At the same time, new energy vehicles for commercial transportation remain in the early stages of development, with even coach buses in China at a minimal 4 percent of electrification.[126] Similarly, Chinese policymakers are focused on high-speed rail freight transportation as they seek to reduce carbon emissions and expand the country's already robust passenger rail networks.[127] Chinese producers and policymakers anticipate great commercial advantage from the sale of these vehicles and related equipment, though the U.S. and other national governments have raised concerns with the security and integrity of the technology.* In China, the movement toward more autonomous commercial transportation may also alleviate future shortages in China's labor force, though it currently threatens nearly 220 million jobs that are largely held by low-wage, low-skilled workers.[128]

International Expansion of China's New Mobility Companies

China is gaining ground in new mobility competition with the United States across all subsectors, demonstrating successful innovations in autonomous and connected vehicle systems, potential for higher NEV exports and control over NEV batteries, and notable capture of ride-hailing markets. AVs have yet to reach broad adoption and, along with NEVs, require newer infrastructure to satisfy digital connectivity or electricity needs. Competition between U.S. and Chinese markets is currently limited due to strong consumer preferences, relative brand strength, and respective domestic policies. In 2021, Guidehouse Insights (formerly Navigant Research), a market research firm focused on energy and transportation research, ranked Baidu's AV subsidiary, Apollo, fourth in its assessment of technological advancement among global autonomous driving systems.[129] U.S. companies Waymo, Nvidia, and Argo AI ranked ahead of Apollo.[130]

Testing and Standards

While Chinese-branded cars are currently not sold in the United States, Chinese AV companies are testing their models on U.S. roads. The United States lacks federal regulations for testing or cybersecurity of AVs.[131] Similarly, there is no clear U.S. federal, state, or local standard for protecting, sharing, and collecting vehicle data in the United States. In 2019, the U.S. Department of Transportation issued a *Data for Automated Vehicle Integration Framework* that outlines principles and guidelines for state and local governments, companies, and other stakeholders on identifying, prioritizing, and sharing data in AV systems.[132] It recommends that AV companies share data with local governments regarding crashes and infrastructure data, but the framework itself is voluntary.[133]

*The 116th Congress addressed concerns over Chinese rail cars and public transportation equipment with the passage of the Fiscal Year 2020 National Defense Authorization Act. Section 7613 prohibits government procurement of bus and rail equipment from a range of countries, including China. This restriction particularly affected BYD, which was poised to be a top exporter of bus and rail equipment to the United States. National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116–92, 2019; Lindsay Wise and Katy Stech Ferek, "Congress Wants to Ban Chinese Buses, Railcars in Defense Bill," *Wall Street Journal*, December 10, 2019.

California AV Testing

Absent federal regulations, states have been issuing their own frameworks for managing AV testing and deployment, with 18 U.S. states allowing for testing of AVs without a human operator in the vehicle.[134] Because of the AV industry's connections to Silicon Valley, California retains a high concentration of AV testing sites and companies. In 2012, California began allowing AV testing, and in 2014 it launched its AV Tester Program to promote this development.[135] As of July 2021, California permitted 54 companies to conduct autonomous testing with a driver, including 23 foreign entities, of which 11 are Chinese.[136] California has granted permits to eight companies to test AVs without a driver, half of which are Chinese; the other half are U.S. companies.*[137] California is one of the few states that provide a publicly available list of participating companies.[138] The notable lack of information elsewhere makes it difficult to verify the presence of companies across states.

California's AV Tester Program and related regulations are rooted primarily in driver safety, but they do not appear to consider specific rules or regulations on data or cybersecurity. AV Tester Program participants are only required to share collision data within ten days of an incident, but they are currently not required to submit to any form of cybersecurity certification. In many other states, like Arizona, no licensing or permits are required to do testing other than regular vehicle registration requirements, and no state or federal U.S. law prevents AV testing otherwise.[139]

Meanwhile, China is developing numerous domestic standards for autonomous, connected, and electric vehicles while Chinese companies remain active participants in global standards-setting bodies. Efforts in multiple standards forums to address various technological components of autonomous and connected vehicles are still at an early stage. Among others, the International Organization for Standardization (ISO) is developing international standards while the International Telecommunication Union (ITU) is pursuing several pre-standardization studies.[140] In 2018, ISO approved a Chinese proposal to form a working group focused on standards development for "test scenarios of automated driving systems" under ISO Technical Committee 22, the primary group under ISO that develops standards for road vehicles.[141] While the formation of the working group "was a milestone for Chinese auto standards," the group's work so far appears to rely on the collaborative efforts of multinational experts.[142] China is also an active participant in the ITU and holds leadership positions in two focus groups on AV-related standards.[143] The structure of the ITU could allow Chinese participants greater influence over the process and the ability to export its standards to

*The eleven Chinese companies include AutoX Technologies, Baidu, DeepRoute.AI, DiDi, Inceptio Technology, Leonis Technologies, NIO, Pony.AI, Qcraft.ai, WeRide, and Xmotors.AI. California Department of Motor Vehicles, "Autonomous Vehicle Testing Permit Holders," May 21, 2021.

developing nations that tend to participate more in the ITU than in ISO.*

Global Mobility-as-a-Service Competition

MaaS competition is most apparent in the area of ride-hailing services, where Uber and Didi continue to vie for dominance across developing markets.† In 2020, Didi reported that it had 600 million monthly active users and aimed to serve 800 million monthly users globally by 2022.[144] By comparison, Uber had 329 million monthly active users in 2020.[145] Over the last five years, Didi has entered 14 other markets outside of China, covering Latin America, Africa, and Oceania.[146] Didi has been closing in on competition with Uber in Latin America, with operations in six countries across the region.[147] In 2018, Didi claimed 30 percent of market share in Latin America following its acquisition of the preeminent Brazilian ride-sharing app 99 (formerly known as 99 Taxis).[148] In March 2021, Didi began offering services in South Africa in its first venture on the continent.[149]

Didi may also hold a data-driven appeal to local governments that have much to gain from Didi's GAIA Initiative. Launched in 2017, the GAIA Initiative shares two of Didi's datasets with registered users such as researchers and government offices and provides a platform for additional research and publications. The anonymized datasets‡ provide information on traffic and ride times to enable more precise transportation planning and assist AI-managed transportation. The GAIA Initiative went global in 2018 and expands along with the company as it gathers more data points in new markets, though public information indicates that much of the data available still centers on Chinese cities.[150] Uber has a similar open platform called Movement for anonymized data sharing that covers 51 cities across markets that Uber serves.[151] Data security has nonetheless been a point of contention between Didi and the Chinese government.[152] In June 2021, Didi listed on the New York Stock Exchange to reach a valuation of $68.4 billion on its first day, but this fell precipitously by 52 percent after Chinese regulators ramped up an antitrust investigation into the company, subjected it to a cybersecurity review, and restricted new user downloads.[153] (For more on tightening Chinese regulation, see "Chapter 2, Section 1, "Year in Review: Economics and Trade.")

*For more information on the international standards development process, see "U.S.-China Economic and Security Review Comission, Chapter 1, Section 2, "The China Model: Return to the Middle Kingdom," in *2020 Annual Report to Congress*, December 2020, 80–135.

†Uber operated in China from 2014 to 2016, ultimately retreating from the market due to strong local preference, Didi's market dominance, and some Chinese regulations that undercut Uber's services. Uber traded shares with Didi such that each company had a member on the others' board seat and Didi assumed control over a dissolved Uber China. Meanwhile, Didi is able to operate in the U.S. market, but the company does not provide rideshare services due to market saturation. Didi does have three research labs in California, including one in Silicon Valley, which focus on research of advanced safety and security technology for transportation, algorithms, and self-driving technologies. James Crabtree, "Didi Chuxing Took On Uber and Won. Now It's Taking On the World," *Wired*, September 2, 2018; William C. Kirby, "The Real Reason Uber Is Giving Up in China," *Harvard Business Review*, August 2, 2016.

‡Didi anonymizes the accumulated ride data for public access by removing personal information removed from start and end points, along with separating travel times from any personally identifiable information. Didi, "GAIA Open Dataset."

NEV Export Competitiveness and Energy Storage

China does not have a clear advantage in the export of finished NEVs, but it is well positioned to compete with other leading automakers in the United States and Germany. NEV growth has slowed in China since the government reeled back subsidies in 2019, though according to Pew Research Center, China still accounted for 44 percent of the world's total NEV stock in 2020.[154] According to McKinsey in 2019, four Chinese brands—BYD, Beijing Electric Vehicle Co. (commonly known as BJEV), SAIC, and Geely—were among the top ten global NEV sellers, together making up 23.9 percent of global NEV sales.[155] Tesla claimed 16.2 percent alone and top German automakers BMW and Volkswagen accounted for 9.6 percent.[156] The success of Chinese companies appears largely attributable to the Chinese market and its home advantage there. In Europe, the second-largest NEV market, Chinese companies made up less than 2 percent of the market in 2019.[157] Although Chinese companies are still a small part of the passenger vehicle market, they are making inroads in Europe and Latin America with the sale of electric buses. In 2019, Chinese company BYD held nearly 20 percent of European NEV bus market share.[158] Meanwhile, Chinese companies produce at least 71.4 percent of the total electric buses in Latin America as of July 2021.[159]

Chinese NEV companies may prove to become more competitive on cost rather than technology or branding when compared to the ever-popular Tesla.[160] Chinese automaker SAIC sold 10,000 units to Europe in 2019 through acquiring British brand MG and has committed to selling 100,000 units annually to Europe by 2025.[161] There are more than 400 Chinese NEV companies, some of which are ready to compete internationally after being backed by extensive subsidies over the last decade.[162] While these companies may lack some of the sophistication in technology and brand appeal, Chinese NEVs are, much like in their home market, likely to come at a much lower cost.[163] Similar to its approach in other industries, Chinese producers could sustain an advantage in the global market by undercutting prices as a result of government support. The proliferation of Chinese NEVs at below-market costs could have significant consequences for global automakers and related manufacturing workers while also raising future questions around overcapacity, particularly concerning batteries.[164]

Cloud Computing at the Core of China's Digital Economy Ambitions

Cloud services form a critical backbone for the deployment of other emerging and foundational technologies, including telemedicine, smart manufacturing, quantum computing, and new mobility. The National Institute of Standards and Technology defines cloud computing as a business model that allows for "convenient, on-demand network access to a shared pool of configurable computing resources… that can be rapidly provisioned and released with minimal management effort or service provider interaction."[165] In other words, cloud computing is not so much a single technology as it is a business model: a cluster of integrated capabilities from analytic infrastructure to servers that can be easily scaled and customized to

suit various storage and operational needs. While cloud computing enables a proliferation of virtual environments and workspaces, it relies on physical data centers, traditional data storage, and hardware (e.g., switches, routers, and servers) in order to function.[166] How the global cloud computing architecture is developed and who controls its operations, data, and access carry significant implications for critical civilian and defense systems. Cloud computing supports a wide range of operations, from managing transmission of electricity across energy grids to battlefield situational awareness in informationized warfare. Cloud computing has appeared in China's FYPs since the 12th FYP (2011–2015) and is still listed in the 14th FYP as a "key industry of the digital economy," with policymakers encouraging migration to the cloud.

China's Strategy in Cloud Computing

Building on its longstanding approach in other sectors, China's strategy for cloud computing has had two key components: protection of the domestic market from foreign competition and extensive state support for buildout of the Chinese cloud computing industry. Industry alliances, standardization efforts, research centers, and government promotion programs at both the central and local levels helped to create a formidable and remarkably closed cloud computing ecosystem in China. Because cloud computing enables broad and often real-time access to information on a given network, the CCP has a political imperative to control cloud computing access and development and prevent free flow of information via the cloud. Between 2010 and 2012, the central government helped to mobilize not only service providers but also other telecommunications companies in China to improve the underlying infrastructure that supports cloud computing.[167] In 2011, the National Development and Reform Commission partnered with the Ministry of Industry and Information Technology and Ministry of Finance to pool $236 million in support of Chinese cloud providers.[168] While these subsidies may appear modest, they were complemented by a panoply of other measures that allowed domestic firms to grow easily in the early days of cloud adoption. Local governments looking to satisfy central government objectives and obtain funding also built data centers as "deliverables" for central government big data and cloud computing plans.[169] Preferential local policies also deferred tax payments and provided preferential housing for recruiting talent.[170] Government-driven initiatives did not prove immediately successful, and nonstate firms have ultimately been far more successful than SOEs like China Mobile, which invested $52 billion between 2011 and 2014 to support cloud services with little market share in return.[171]

Promotion of cloud computing has always been essential to the CCP's goal of maintaining information control. It has also been tied to the Chinese government's efforts to grow other emerging technologies, such as smart cities.[172] It is difficult to estimate the total spending on cloud computing-related technologies, but a majority of Chinese digital infrastructure projects that receive government financing will contribute to cloud computing capacity in China by expanding storage and analytical capacity. Under the Internet Plus initiative, launched in 2015, the Chinese government dedicated at

least another $440 million in infrastructure spending from 2016 to 2018.[173] Amid a raft of COVID-19-related stimulus measures in 2020, the Chinese government announced a "new infrastructure" initiative of nearly $1.4 trillion over six years between 2020 and 2025 to increase the number of data centers and networking equipment to support cloud computing, 5G, AI, and smart cities.[174]

Relying on the government's support, Chinese cloud companies have had fewer obstacles to operating than their foreign counterparts, though they are still subject to stringent security requirements given the government's concerns around information control. Today, China is the second-largest cloud services market after the United States and in 2019 accounted for 5 percent of global public cloud services spending.[175] According to market research firm Canalys, Chinese companies Alibaba, Tencent, and Huawei dominate the domestic cloud services market.[176] These three Chinese companies make up 72 percent of domestic market share.[177] Foreign companies as a group, which includes Amazon Web Services and Microsoft Azure, account for less than 20 percent of the Chinese market.[178] The total market in China grew 30 percent each year from 2015 to 2019 and demand increased by nearly 70 percent in 2020 alone as a result of the COVID-19 pandemic.[179] Alibaba is far and away the leader in China's cloud market, with Tencent its nearest competitor, followed by Huawei, Baidu, and China Telecom.

The Chinese government has boosted incentives for Chinese cloud providers toward sector-specific cloud-based solutions that will support CCP objectives for social development and provide technological solutions for China's greatest growth challenges. In 2015, Alibaba formed a partnership with BGI and Intel Corporation to launch a cloud platform for precision medicine, which takes genetics, lifestyle, and environment into account.[180] Along with its AI Open Lab, Tencent announced a cloud services offering that allows patients to manage their medical imaging and securely share the images with different medical providers.[181] In 2016, with the help of its auto subsidiary, Apollo, Baidu worked with the Ministry of Transport to offer an open data platform that provides publicly available transportation and traffic data, including data shared by companies and research institutes.[182]

International Expansion of China's Cloud Companies

Chinese companies are increasingly looking to compete with cloud service providers in emerging markets. Being somewhat late to arrive in the United States, Chinese cloud providers do not have a sizable portion of U.S. market share, though some have partnerships with U.S. companies like Equinix or have built data centers in the United States.[183] In 2019, U.S. imports of Chinese cloud computing and data services were a mere $10 million, which is less than 2 percent of total U.S. cloud services imports globally.[184] Chinese cloud computing companies appear to have largely given up on market share in already saturated markets like those in North America and Europe. U.S. cloud leaders like Amazon Web Services, Microsoft, Google, and IBM capture over 60 percent of global market share, even with barriers in China's market.[185]

China's cloud computing giants are gaining ground in emerging markets, where competition is set to intensify with U.S. companies. According to Nigel Cory, associate director for trade policy at the Information Technology and Innovation Foundation, "China is ahead of the United States and many others . . . in terms of advocating for its digital and [information and communications technology] firms and associated projects as part of its [Belt and Road Initiative] and the Digital Silk Road initiatives."[186] U.S. companies continue to retain an edge due to processes that allow large organizations the most up-to-date and seamless experience in data processing and analytics.[187] At the same time, Chinese companies have the advantage of a lower price point (sometimes operating at a loss* and creating an unfair advantage) with fewer up-to-date products but greater flexibility to accommodate unique data localization and information control policies.[188] Chinese companies like Alibaba also appeal to some markets by promising big investments in the host country tech sector, such as commitments to build data centers and other tech infrastructure.[189] Huawei has taken a similar approach as it has focused on the growth of its cloud computing business, partnering with foreign governments and SOEs on cloud infrastructure and services (Figure 3).[190]

Although U.S. companies remain the dominant global cloud providers, Chinese companies are gaining ground. According to global advisory firm Gartner, Alibaba claimed 9.5 percent of global market share for public cloud services in 2020 compared to 8.8 percent in 2019 while Huawei's more than doubled from 1.9 percent to 4.2 percent in the same period.[191]

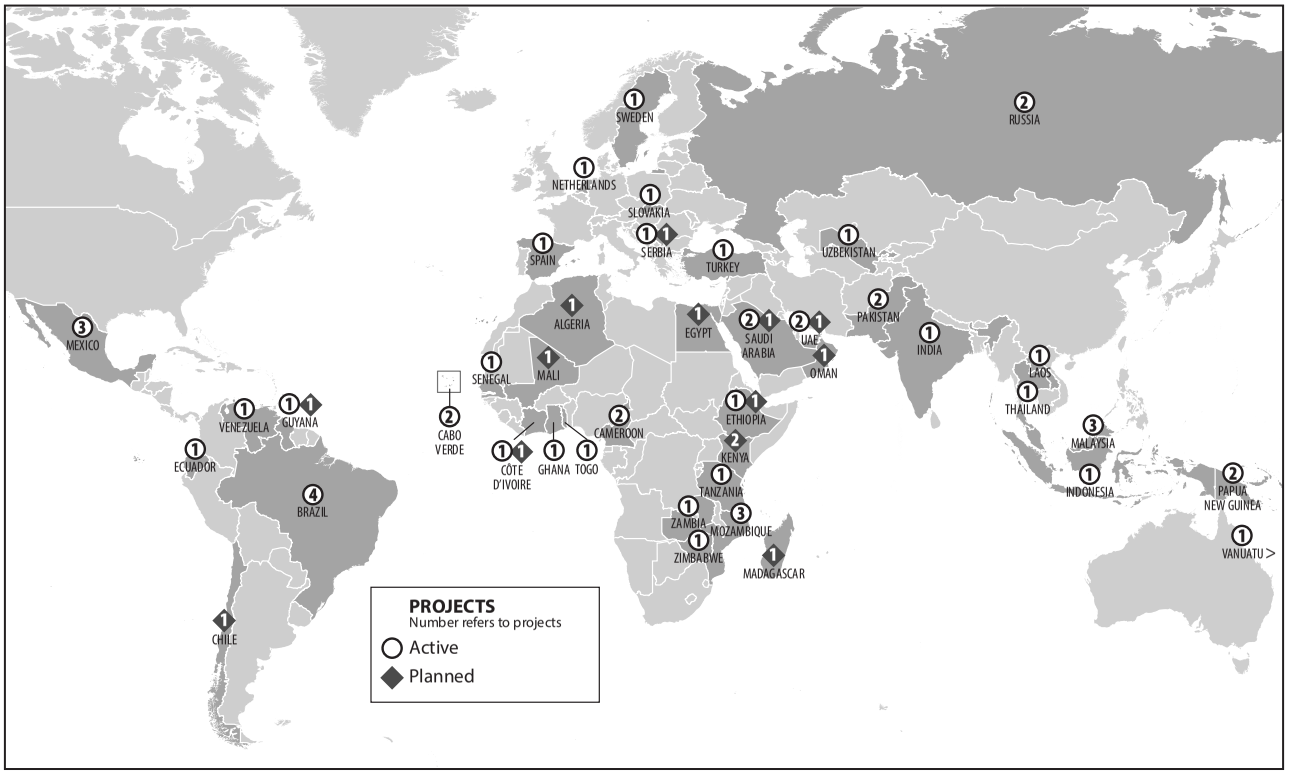
Extensive investment in data infrastructure and tolerance for more restrictive data policies have given Chinese cloud providers a head start on market share in Southeast Asia and other developing economies.[192] Mr. Cory notes that for India, Vietnam, and other Southeast Asian countries with restrictive data localization policies, Chinese companies have a competitive advantage in their willingness to build out isolated data center operations or tailor their offerings to country-specific censorship and content-monitoring regimes.[193] U.S. companies have historically resisted rules that broadly infringe on consumer privacy for law enforcement and national security investigations, as well as data localization rules that would require building in-country data centers, which can come at significant cost.[194]

China's Promotion of a Sovereign Digital Currency

The Chinese government believes that a digital version of the RMB can help it increase control over China's financial system and surveillance over those who participate in it. The government has also stressed the potential for a central bank digital currency to allow for greater financial efficiency and inclusiveness. Therefore, the CCP has made the development of the digital RMB a key priority, announcing in 2016 a "strategic goal" of launching a digital currency.[195] Since then, China has emerged as one of the leading

*Alibaba Cloud, the largest cloud provider in both China and the Asia Pacific region, turned profit only in 2021 after 11 years in operation. A statement from the company noted this was due to achieving "economies of scale." Rita Liao, "Alibaba Cloud Turns Profitable after 11 Years," *Tech Crunch*, February 3, 2021.

Figure 3: Huawei's Overseas Cloud Computing Projects



Source: Reconnecting Asia Project, "Reconnecting Asia Huawei Cloud & e-Government Data," *Center for Strategic and International Studies*, April 2021.
Note: "Planned" indicated projects that have been signed through a contract or memorandum of understanding.

countries in researching and developing central bank digital currencies. While supporting the development of a digital RMB, the CCP has sought to prevent the growth of other digital currencies. In October 2020, the People's Bank of China (PBOC) published a draft law that, if passed, would officially recognize the digital RMB and would ban the circulation of other digital currencies or tokens.[196] The 14th FYP reaffirmed China's ambitions for the digital RMB, with an objective to "steadily advance digital currency R&D."[197] As digital payments are already dominant in China through platforms such as Alipay and WeChat Pay, the introduction of a digital RMB does not represent a seismic shift in China's financial landscape. Absent fundamental changes to China's monetary policy, such as the relaxing of its strict capital controls, a digital RMB will not significantly enable the RMB to be used more broadly in cross-border transactions. Nevertheless, China's development of the digital RMB is significant because it will help the CCP expand its surveillance regime. In the longer run, the digital RMB could also reduce China's reliance on the United States-led international system while helping China increase its own influence in other domains, such as the internet.

China has not yet officially launched its digital RMB, which it refers to as Digital Currency and Electronic Payments (DCEP), and many key details of the digital RMB have not yet been publicly confirmed.[198] China has carried out significant testing, however, with trials beginning in four cities in May 2020 and expanding since then to 11 cities and pilot areas.[199] According to a July 2021 PBOC white paper, as of June 2021 more than 20 million personal wallets and more than 3.5 million corporate wallets have been opened, with a total transaction value of approximately $5.4 billion (RMB 34.5 billion).[200]

What Are Digital Currencies?

"Digital currency" is an umbrella term for any money that exists only in electronic form and is not available in physical form.[201] Over the past decade, different forms of digital currencies have appeared. These digital currencies share similar characteristics but differ in important aspects.

Cryptocurrency. Cryptocurrency is a type of digital currency that uses encryption and whose transactions are verified using a decentralized network of computers rather than a centralized bank-based database. Bitcoin is a well-known example of a cryptocurrency. Cryptocurrencies use a distributed ledger technology, typically blockchain, which verifies the validity of transactions through a network of computers using cryptographic tools and third parties rather than through a central banking authority. This process allows cryptocurrency transactions to be pseudonymous. Many cryptocurrencies, including Bitcoin, are not linked with government money or a commodity. These cryptocurrencies are subject to volatile fluctuations in value and are often used as speculative assets rather than means of payment.[202]

What Are Digital Currencies?—*Continued*

Central Bank Digital Currency (CBDC). These are digital currencies issued and backed by sovereign central banks. They may be, but are not necessarily, cryptocurrencies.[203] China's central bank digital currency will not be a cryptocurrency, as the Chinese government does not want to replicate in its sovereign currency the pseudonymity or distributed nature of cryptocurrencies. Instead, the PBOC will retain the ability to precisely monitor and approve transactions.[204]

Digital Currency/Electronic Payments (DCEP). This is Beijing's nomenclature for its digital currency payments ecosystem. The term refers not only to the digital RMB but also to the electronic payment tools that will link with the digital RMB, such as those offered by Alipay and WeChat Pay.[205]

Stablecoin. This is a privately issued type of cryptocurrency whose value is tied to government-issued paper or coin money, such as the U.S. dollar, or a commodity such as gold. Stablecoins have more consistent values compared with other cryptocurrencies such as Bitcoin, offering the speed and efficiencies of digital currency without volatility in market pricing. A well-known stablecoin is Diem (formerly Libra), created by Facebook and pegged to the U.S. dollar, which was first proposed in 2019 and set for launch later in 2021.[206] Chinese regulators have expressed views that a dollar-backed stablecoin could cement U.S. dollar hegemony while increasing the possibility of destabilizing cross-border capital flows.[207]

The CCP's Motivations for Promoting the Digital RMB

The CCP's immediate goals for the digital RMB are domestic and focus on shifting how the economy operates and what types of data can be collected. These aims of the digital RMB complement other efforts by the CCP to "informationize" the economy.[208] The CCP also has longer-term international aims, however, based on the idea that digital currency will be an important aspect of geopolitical competition.[209] As Miles Yu, senior fellow at the Hudson Institute and former principal China policy and planning advisor at the U.S. Department of State, testified before the Commission, "China views the digitization of national currencies as an opportunity to increase its surveillance of its own people and to upend the U.S. dollar-dominated global trade settlement and transactional monitoring systems."[210] In an indication of the CCP's international ambitions, in March 2021 during a seminar at the Bank for International Settlements a PBOC official proposed a set of global rules for the interoperability of central bank digital currencies.[211]

Promoting Efficiency in China's Financial System

In promoting a sovereign digital currency, PBOC officials have highlighted the greater efficiency that digital payments can bring to China's economy. The PBOC's 2016 announcement of the digital RMB as a strategic goal outlined several advantages of digital

payments, including greater efficiency, more financial inclusion, and lower costs in comparison to handling cash.*[212] Martin Chorzempa, senior fellow at the Peterson Institute for International Economics, testified before the Commission that the technical innovations of central bank digital currencies are less significant than they first appear, as digital payments, including on nonstate payment platforms, are already dominant in China.[213] The distinguishing feature of sovereign digital currency is that the money is a liability of the central bank rather than a liability of the bank that provides the customer's account (known as commercial bank money). Because central banks can legally create more money, payments using central bank digital currencies are theoretically less risky than those using commercial money.[214]

Preventing Challenges from Other Digital Currencies

The CCP views private cryptocurrencies such as Bitcoin or Diem (formerly Libra) as potentially destabilizing because of their ability to facilitate unregulated capital flows in and out of China. Moreover, the anonymous nature of transactions with these currencies lessens the Chinese government's ability to monitor economic activity. In 2017, concerns over these cryptocurrencies led Chinese regulators to ban the sale of newly minted digital currencies such as Bitcoin on Chinese exchanges, further cementing the government's role in digital currencies.[215] In May 2021, amid an increase in speculative trading of Bitcoin, financial regulators in China expanded the restrictions against cryptocurrencies, including banning financial institutions in China from providing an exchange between cryptocurrencies and the RMB.[216] In September, Chinese regulators banned all cryptocurrency transactions in China, including through offshore exchanges.[217] Chinese regulators see the implementation of a sovereign digital currency as an urgent part of CCP efforts to prevent challenges from private digital currencies. After Facebook announced its plans in 2019 to introduce a stablecoin, PBOC digital currency research leader Mu Changchun said the PBOC's digital RMB team was working around the clock in response to Facebook's announcement, reflecting Beijing's sense of urgency to develop a digital currency before an alternative gains prominence.[218]

Co-Opting Chinese Nonstate Payment Platforms

The CCP's promotion of a digital RMB reflects Beijing's increasing exercise of control over China's nonstate fintech firms, particularly in the mobile payments industry.† Unlike privately issued digital currencies, mobile payments are conducted in RMB and thus are not an inherent challenge to the PBOC's authority. Indeed, Chinese regulators encouraged the growth of nonstate mobile payment firms in the early 2010s, viewing them as an important source of modernization for China's banking industry. As Mr. Chorzempa testified

*According to the PBOC, the digital RMB is intended to serve as a substitute for physical cash in circulation, though will exist alongside physical cash rather than replace it. It is not intended to serve as a substitute for other ways to store money, such as bank deposits. Working Group on E-CNY Research and Development of the People's Bank of China, *Progress of Research & Development of E-CNY in China*, July 2021.

†In Q3 2019, transactions on third-party mobile payments in China totaled approximately $8.7 trillion (RMB 56 trillion). *China Banking News*, "China's Mobile Payments Market Grows over 15% in Q3 2019, Alipay's Market Share Exceed Half," January 21, 2020.

before the Commission, the relationship became more complicated after 2016 due to faster-than-anticipated growth of the sector, the exposure of Ponzi schemes, and risky microlending practices.[219] Regulators are also concerned over the duopoly power of two firms, Alipay and WeChat Pay, which together hold a 94 percent share in China's mobile payments market.*[220]

Rather than replacing AliPay and WeChat Pay, however, the PBOC intends to incorporate them fully into the digital RMB system. Since 2016, PBOC officials have articulated a plan for a two-tiered system under which the PBOC issues the digital RMB while financial firms (both banks and mobile payments companies) distribute them through online wallets. Such an arrangement will allow the PBOC to take advantage of the firms' innovative capacity as well as their existing customer base and user data, increasing its oversight of financial transactions in China.[221]

Enhancing the CCP's Financial Monitoring and Surveillance Capabilities

Samantha Hoffman, senior analyst at the Australian Strategic Policy Institute (ASPI), argued in her testimony before the Commission that while the digital RMB does not create fundamentally new forms of political control, it can enhance the existing monitoring and surveillance capabilities of the CCP.[222] In a recent ASPI report on the digital RMB, Dr. Hoffman and her coauthors argued that while China's central bank digital currency "may address some financial governance challenges, such as money laundering, it would also create unprecedented opportunities for surveillance," including tracking financial activities of Uyghurs and other persecuted minorities under the guise of addressing "terrorist financing."[223] The adoption of a digital RMB also strengthens the CCP's push for technology-driven governance, particularly in the financial sector.† According to Mr. Mu, digital RMB users may remain anonymous to counterparties but will still be required to register their real names with the government in all but small transactions, allowing the PBOC to "achieve traceability under certain conditions and ensure that regulatory technologies such as big data analysis are useful."[224] PBOC officials have termed this "controllable anonymity."[225]

Potential Links to China's Social Credit System

The digital RMB system, and the ability that it could give the CCP to both monitor and prevent financial transactions, could be used with China's Corporate Social Credit System. Launched in 2014, the Corporate Social Credit System collects government records and corporate compliance data into "Corporate Social Credit

*While AliPay and WeChat Pay remain primarily focused on China's domestic market, they have made some expansion abroad. Alipay also has expanded e-payment operations globally and is available in 47 U.S. jurisdictions and 110 countries. According to Mr. Chorzempa, this expansion abroad has so far been relatively modest and mostly consists of Chinese tourists using the platforms while traveling abroad. Martin Chorzempa, written testimony for U.S.-China Economic and Security Review Commission, *Hearing on An Assessment of the CCP's Economic Ambitions, Plans, and Metrics of Success*, April 15, 2021, 4; Nationwide Multistate Licensing System, "NMLS Consumer Access: Alipay US, Inc."

†In 2019, the CCP released a three-year fintech development plan that prioritized big data and artificial intelligence in the financial sector. Yaya J. Fanusie and Emily Jin, "China's Digital Currency: Adding Financial Data to Digital Authoritarianism," *Center for a New American Security*, January 2021.

Files" for every domestic and foreign legal entity in China.[226] Companies with poor social credit scores can be placed on "blacklists," with consequences including restrictions on issuing stock, restricted access to government subsidies, and suspended approvals for R&D projects. Similarly, companies with high social credit scores are eligible to be placed on "redlists," with incentives such as fast-tracked approval procedures, reduced inspections, and preferential quotas for imports and exports.* As with the digital RMB, the PBOC has played an important role in planning the Corporate Social Credit System. According to Dr. Hoffman, while CCP sources have not explicitly linked the two systems, the financial transaction data generated through digital RMB payments could be integrated with the social credit system, which covered more than 60 million organizations and enterprises in China at the end of 2020.[227]

The CCP envisions control via the digital RMB to extend not just to commercial transactions but also to individuals, including Party members. In June 2020, the Central Commission for Discipline Inspection, China's top anticorruption body, published an article saying the digital RMB would counter crimes that "cannot be tolerated," such as bribery and corruption.[228] The enhanced surveillance capabilities could be used to further the CCP's efforts to exercise control over Chinese citizens. In September 2020, the manager of China Construction Bank's fintech lab said at a virtual panel that the bank's fintech projects would incorporate China's "blacklist."[229]

Reducing Reliance on the Dollar-Led Financial System

Internationalizing the RMB

In 2018, Fan Yifei, deputy governor of the PBOC, stated that a digital currency could promote RMB internationalization, which has been a significant goal of the CCP since the 2008 financial crisis.[230] In theory, the digital RMB could support internationalization of the RMB by enabling easier and more widespread use of the currency in cross-border payments. According to a January 2021 report from the Center for a New American Security, Beijing will likely pursue policies to encourage adoption of digital RMB transactions by foreigners visiting China and could require Chinese citizens to use digital RMB when traveling abroad. Such measures, however, are unlikely to lead to substantial internationalization of the RMB.[231] Observers agree that the greatest impediments to internationalization of the RMB are China's restrictions on capital flows and the opacity of the RMB's exchange rate policy, which the digital RMB does nothing to address.[232] In May 2021, Zhou Xiaochuan, former chairman of the PBOC, downplayed the role of the digital RMB in internationalizing the RMB, saying that while the digital RMB could make small cross-border payments more convenient, this development "is not in the sense of a reserve currency, nor is it the internationalization of the RMB in the sense of large-value transactions in the financial market."[233]

*For more on the Corporate Social Credit System, see Kendra Schaefer, "China's Corporate Social Credit System: Context, Competition, Technology, and Geopolitics," *Trivium China* (prepared for U.S.-China Economic and Security Review Commission), November 16, 2020.

SWIFT and the Impact of U.S. Sanctions

The digital RMB has the potential to reduce China's reliance on SWIFT,* which the Chinese government views as a source of vulnerability. In 2019, Huang Qifan, chair of the China Center for International Economic Exchanges, argued that developing a digital RMB would help guard against the United States' ability to "exercise global hegemony and carry out long-arm jurisdiction" through SWIFT as well as the Clearing House Interbank Payments System (CHIPS), which is a U.S. clearinghouse for financial transactions.† [234] Aside from establishing the digital RMB, the CCP has already engaged in some efforts to reduce China's reliance on SWIFT and CHIPS. A July 2020 report by the Bank of China called for banks in China to increase their use of China's Cross-border Interbank Payments System, citing the risk of exposing financial payment information to the United States via SWIFT as well as the risk that the United States could cut off Chinese banks' access to SWIFT.‡ [235]

If eventually adopted around the world, the digital RMB could reduce China's vulnerability to U.S. sanctions, as it could provide the same transfer capabilities as SWIFT and CHIPS without the need for intermediary institutions.[236] Other countries that are susceptible to U.S. sanctions, such as North Korea or Iran, may also decide to use the digital RMB to bypass sanctions.[237] In the short term, however, most economists believe that the digital RMB is unlikely to significantly change the CCP's ability to evade U.S. financial sanctions. In fact, the more comprehensive financial data under the digital RMB could provide a disincentive to attempting to evade sanctions. In testimony before the Commission, Mr. Chorzempa said the adoption of the digital RMB could make evading U.S. sanctions more difficult for the Chinese government because the PBOC's monitoring capabilities of digital RMB payments would prevent the Chinese government from having any deniability of sanctions evasion.[238]

Potential Connection to Blockchain-Based Service Network

While the CCP has restricted the use of blockchain-based cryptocurrencies such as Bitcoin in China, Chinese regulators nevertheless want to develop a blockchain network with global users and applications. In 2019, General Secretary Xi said that blockchain "plays an important role in new technical innovation and industrial transformation" and called for China to increase its blockchain R&D, including in setting international blockchain standards.[239] In 2020, China's main economic planning agency, the National Development and Reform Commission, further demonstrated the CCP's commitment to blockchain, classifying it as part of a new model of

*SWIFT (the Society for Worldwide Interbank Financial Telecommunications) is a messaging system that facilitates most of the world's banking transfers. SWIFT has been instrumental in enforcing U.S. financial sanctions, disconnecting sanctioned banks from the system. Mark Dubowitz, "SWIFT Sanctions: Frequently Asked Questions," *Foundation for Defense of Democracies*, October 10, 2018.

†CHIPS (Clearing House Interbank Payments System) is a private sector money transfer system used for electronic payments settled in U.S. dollars. OFX, "What Is CHIPS?"

‡CIPS (Cross-Border Interbank Payment System) is an alternative to SWIFT created by China in 2015. In 2018, CIPS handled $3.7 trillion, while SWIFT handled $40 trillion. Kayla Izenman, "DC/EP's Potential Internationalization and the Global Economy" in "The Flipside of China's Central Bank Digital Currency," *Australian Strategic Policy Institute*, October 2020.

infrastructure, along with cloud computing and AI, that will form an important part of China's information technology.[240]

In an effort to claim global leadership in blockchain development, in 2020 China's government launched the Blockchain-Based Service Network (BSN), which is an international cloud computing network with the capability of supporting blockchain-based applications.[241] According to Yaya Fanusie, adjunct senior fellow at the Center for a New American Security, the BSN is not a separate internet but rather "a system of low-cost backend architecture on which software developers around the world can build blockchain applications—including digital assets such as cryptocurrencies."[242] As of November 2020, the BSN has 131 data centers located on every continent except for Antarctica.[243] The BSN has already partnered with international firms, including some from the United States, for blockchain development projects, due in large part to the lower cost of developing projects versus through traditional cloud service providers.[244]

The BSN architecture is bifurcated between Chinese and international users. Data servers for Chinese users and international users are physically separate, and internet users within China will not be able to access many of the blockchain applications developed on the BSN.[245] Nevertheless, both the domestic and international services fall under CCP control. At a 2020 Hong Kong fintech conference, Tan Min, secretary general of the BSN, stated that the BSN would create an internet where "China controls the rights to [blockchain] internet access."[246]

China's government has not yet directly linked the digital RMB to the BSN, but it is likely that both the domestic and international versions of the BSN will incorporate central bank digital currencies. CCP officials working on the BSN have discussed the use of the BSN to streamline online payments, and as Mr. Fanusie testified before the Commission, because China will not allow for private cryptocurrencies to be used on the domestic BSN, "it is logical to conclude that the payment instrument for such transactions will be the digital RMB."[247] Internationally, Chinese officials also expect the BSN to use foreign central digital bank currencies. A January 2021 blog post outlined BSN plans to establish a universal digital payment network by 2026 based on central bank digital currencies of various countries and "enable a standardized digital currency transfer method and payment procedure."[248]

Implications for the United States

The Chinese government sees itself as competing directly with the United States for global economic leadership, a rivalry where technological prowess will play a central role. China's pursuit of innovation also includes a struggle for influence over international standards in a range of key technologies that the CCP sees as drivers of the next-generation global economy. The United States may be facing a short, sharp competition with China, but leadership in foundations of future economic growth hangs in the balance.

To mitigate perceived comparative disadvantages, the CCP is strengthening its tools for top-down direction, making it more difficult to determine the extent of its influence and control over the nonstate sector. U.S. policymakers and businesses would benefit from a

more detailed understanding of connections between the Party and nonstate firms, which may assist in preventing and mitigating risks. As the Chinese government intensifies pursuit of self-sufficiency across a range of emerging technologies, U.S. businesses can anticipate more intense competition from Chinese actors both in China and in third-country markets. Even where China is not able to succeed in its ambitious goals, its implementation of a grand strategy still can have significant consequences for U.S. national and supply chain security, competitiveness, and jobs.

The CCP's promotion of synthetic biology, including its support of national champions like BGI, could make China the global leader in an emerging field with transformative potential for the future of economic development, environmental protection, healthcare, and national security. China's growing synthetic biology capabilities are not inherently harmful to U.S. interests. Indeed, Chinese developments in synthetic biology, if shared with the world on a reciprocal basis, have the potential to benefit both U.S. and Chinese interests, including through the provision of cutting-edge medical treatments. In practice, however, the CCP views scientific research as a zero-sum contest. China's massive worldwide collection of genomic data—particularly from smaller countries that do not fully appreciate the value of their genetic diversity or have the ability to protect it—gives the CCP the opportunity to enshrine this closed model in emerging international standards for synthetic biology. Since China's track record has not been that of a trusted and reciprocal partner, this could challenge the U.S. tradition of open scientific ecosystems and eventually give China an insurmountable advantage over the United States in the field.

Chinese advantages in new mobility technologies pose a distinct risk to U.S. automakers and workers. China is pursuing a price-competitive strategy for NEVs in third-country markets and is leveraging its influence in international standards bodies to promote its domestic standards for AVs. Without a clear strategy that includes continued investment in R&D as well as participation in international standards setting, the United States could lose competitive advantage in this field. U.S. federal, state, and local governments must also anticipate vulnerabilities in digital infrastructure around Chinese autonomous and connected vehicle operations and may need to contend with exploitation of U.S. digital infrastructure. U.S. companies may be shut out of NEV battery supply chains due to China's state-driven control over critical minerals and dominance in refining and battery production. If China cuts off access to key inputs as part of its offensive decoupling strategy, U.S. companies may struggle to avoid critical shortages without domestic alternatives or cooperation with allies. China has shown willingness to weaponize and politicize supply chains.

Steady growth of China's cloud computing industry strengthens its overall technological capabilities and enables the growth of other strategic industries, such as AI, quantum computing, and smart cities. U.S. cloud computing companies are in a close race for market advantage with Chinese competitors. The growth of Chinese cloud computing companies in emerging markets may also have longer-term consequences for the future of digital rules and encourage

the proliferation of techno-authoritarianism. Greater Chinese influence and competitiveness heighten the risk that Chinese technical standards and security assessments around cloud computing and cross-border data transfer will gain traction in developing markets, undermining the competitiveness of U.S. firms in these markets.

China's development of a sovereign digital currency bears short- and long-term implications for the United States. In the short term, U.S. citizens and companies operating in China could have their financial payments subject to greater CCP monitoring. Potentially, it would be easier for the CCP to impose economically coercive actions against U.S. individuals and firms, including preventing financial transactions of U.S. firms that do not conform to Beijing's policy preferences. In the longer term, China's development of a sovereign digital currency could pose even greater challenges to U.S. leadership of the global financial system. Currently, the greatest impediment to internationalization of the RMB is China's capital controls, which will not be affected by the introduction of the digital RMB. If the CCP does change its capital controls, however, the use of the digital RMB could ease cross-border use of the RMB, thereby aiding internationalization. Similarly, although the digital RMB does not currently undermine U.S. financial sanctions, in the future it could facilitate financial payments that bypass SWIFT and CHIPS, placing them beyond the reach of U.S. financial sanctions.

ENDNOTES FOR SECTION 2

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