The Commanding Heights of Global Transportation

SAFE

Letter to the Reader

The 21st century will be defined by the relationship between the United States and China, a nation which has rapidly emerged as the largest rival to American influence and leadership on the world stage. Lest there be any doubt, the COVID-19 pandemic has vividly illustrated the current nature of this relationship and the vulnerabilities it creates for the United States, which is overwhelmingly dependent on supply chains in critical sectors running through China.

Guiding China's economic rise is *Made in China 2025*, a strategy that seeks to raise the country's global standing by taking commanding leadership positions in a variety of emerging industries of economic and strategic significance. Central to this strategy is consolidating control of the important supply chains for the future global transportation industry, from mineral extraction and processing, to electric vehicle battery and motor production, development of autonomous vehicles and 5G technology on which cars will communicate, the design and assembly of electric vehicles, and the deployment of charging infrastructure and battery storage.

The world is beginning the most important shift in the movement of people and goods since the invention of the automobile, and the United States must ensure that its vehicle manufacturing and transportation industry is prepared to compete. The next-generation of vehicles and mobility will be electric, connected, and likely autonomous—with batteries and motors, software, wireless communication, and artificial intelligence being critical. This has opened the industry to new entrants, players, and even countries, as the sector shifts away from the internal combustion engine.

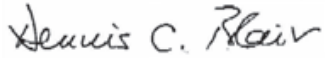
Beijing's ambitions threaten the viability of the entire U.S. automotive and truck manufacturing industry, or at the very least have provided China with a tremendous comparative advantage. The advanced manufacturing backbone of the U.S. economy, the auto industry specifically not only supports 10 million direct and indirect jobs, but accounts for more than three percent of GDP. Moreover, the industry has a highly skilled workforce that our nation has turned to in times of crisis. During World War II, our auto and transportation companies became the "Arsenal for Democracy," repurposing their people, plants, and manufacturing processes to build tanks, bombers, and trucks at unprecedented scale. Those same companies were recently deployed as an "Arsenal for Health" to combat COVID-19 by making ventilators and other medical equipment.

The United States cannot afford to lose the manufacturing capacity—people, equipment, research and development, and management and organizational skills—of a vibrant and healthy vehicle industry. If such manufacturing capacity is lost, or severely degraded, it would not only threaten our economy and millions of jobs, but it could also undermine our capacity to innovate, with implications for the military and defense industry.

As the United States awakens to these risks, we must adopt a long-term comprehensive strategy—from minerals to markets—that overcomes political discord in Washington. This report contains a series of policy recommendations necessary for the United States to maintain the commanding heights of global transportation. These recommendations will ensure that we do not swap our current dependence on an unstable oil market for reliance on China for our future transportation needs. Above all, it notes that bipartisan support is needed if we are to counter these threats and create a transportation system that truly works in our national interest.

Sincerely,

Robbie Diamond
Founder, President and CEO
Securing America's Future Energy



Admiral Dennis Blair (Ret.)
Former Director of National Intelligence and
Commander-in-Chief, U.S. Pacific Command

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Summary for Policymakers

The devastation wrought by coronavirus has revealed the vulnerability of the U.S. economy, and even the health of Americans themselves, to supply chains in critical sectors running through China. Relying on China for critical goods—such as medicines and medical supplies, advanced electronic components, and other manufactured products—jeopardizes the health and security of the U.S. economy.

As America begins to recover from the pandemic, U.S. policymakers must reassess how to maintain its dominant position in the global economy, and how to forestall ceding leadership to China.

While navigating the post-pandemic world, the United States will need to carefully balance competing geopolitical and economic interests. The United States, for example, must continue to participate in the rules-based international trading system predicated on free market principles, because when foreign trade is fair, it strengthens the economy and improves the lives of average Americans.[1] In the late 1990s, much of the foreign policy establishment agreed that integrating China into the international system would provide myriad benefits to the U.S. economy, and encourage Beijing to abide by global trade rules.[2] The American worker, however, paid a penalty in jobs lost to China, and it has become clear that China's ambition is to take advantage of some international business rules and practices, and to disregard others in order to favor and grow its own companies at the expense of American and other foreign businesses. China subsidizes domestic companies, penalizes and exploits their international competitors, and coerces intellectual property from American and other foreign businesses around the world. The Chinese government systematically encourages and supports, through both legal and sometimes illegal means, the international expansion of Chinese companies.

Taken as a whole, Beijing's actions should be deeply concerning to policymakers. The United States must respond by bolstering its technological advantage and domestic industrial capabilities, which serve as the backbone of American economic power. Since the invention and mass production of the first Model-T, the U.S. automotive industry has been a foundational industrial sector of the economy, and it has been at the cutting edge of innovation in materials, engineering, digital design, and computing. The automobile is increasingly crucial to high-tech innovation, and leadership in automotive and related technologies has important implications for future U.S. economic competitiveness. The auto industry is one of the largest manufacturing sectors in the United States, and the industry's extensive supply chains support regional economies while exports improve our balance of trade.[3] Today, China is undermining that industry, and challenging the United States for leadership over the future of the global automotive market.

The world is beginning the most important shift in transportation since the invention of the automobile, and the United States must ensure that its automotive industry is prepared to compete. Driven by the convergence of Detroit and Silicon Valley, American ingenuity could lead a global innovation revolution of historic proportions—one that meaningfully accelerates adoption of advanced fuel vehicles, and the development of autonomous and connected vehicle technologies. American leadership in these technologies could generate important benefits for the country, including increased energy and national security, manufacturing competitiveness, employment growth, and the assurance that the nation will retain its position atop the global economic order.

Yet, for as much promise as America's advancements in emerging transportation technologies hold for the country's outlook, the United States faces an uncertain future replete with profound risks. China, with its increasingly assertive stance on the international stage, is challenging the United States for global leadership over the next generation

1 Rachel McCulloch, "The International Trading System and Its Future," Oxford Handbook of International Commercial Policy, November 2010.

2 Lael Brainard, "Trade Policy in the 1990s," The Brookings Institution, June 29, 2001.

3 Kim Hill, Debbie Maranger Menk, and Adam Cooper, *Contribution of the Automotive Industry to the Economies of All Fifty States and the United States*, Center for Automotive Research, April 2010, at page 1.

of mobility. After decades of economic preeminence, the United States must now contend in a world in which a rising China is moving up the manufacturing value chain and competing in advanced technology industries.

Despite the challenges presented by China's whole-of-nation industrial policy, the United States is still the most innovative nation in the world. It remains in a position of exceptional strength with vast natural resources, capital markets, and a large consumer market. However, keeping America prosperous and secure depends on a sustained and two-pronged strategy that will help America rise to the challenge. First, the United States must prioritize public policies that accelerate innovation, safeguarding its position as the global technology leader. Moreover, it must put millions of EVs on the road quickly, to achieve the scale that will ensure a prominent global manufacturing and supply chain position. Second, the United States must counter China's mercantilist economic practices in close coordination with its allies. Such an approach will ensure that both America and its automotive industry are prepared to compete with China for decades to come.

China's Emergence as a Competitor to the United States

Prior to China's accession to the World Trade Organization (WTO) in 2001, the prospect that China would challenge the United States for global economic leadership was of little concern to U.S. policymakers. In 2000, China was already the sixth largest economy, but the country was focused primarily on labor-intensive low- and mid-technology manufacturing.[4] At that time, the United States believed its actions would accelerate China's transition to a market-based economy, force Beijing to adhere to global trade norms, and liberalize its political system. In hindsight, this broadly held view has proven incorrect. Over the first two decades of the 21st century, many U.S. corporations profited from greater access to a colossal new market, while U.S. consumers enjoyed the savings from cheaper imported Chinese goods.[5] Trade in goods between China and the United States soared from $116 billion in 2000 to nearly $560 billion in 2019.[6] Unfortunately, the notion that China would conform to an international system that the United States helped design without Beijing's input was fundamentally misguided.

China benefited greatly, and perhaps disproportionally relative to the United States, from its integration in the global market, and is now the second largest economy in the world. It has accomplished this while maintaining firm party control over nearly every aspect of its society.[7] China has consistently flouted global trade rules and used the market-based system to its advantage by granting illegal state subsidies to companies, implementing import and export quotas to control supply chains, engaging in forced technology transfer and outright intellectual property theft, and by discriminating against foreign firms.[8] Though it has remained behind in developing the most cutting-edge technologies that will define the future global economy, Beijing's tactics have enabled China to become competitive in many industries.[9]

In 2015, Beijing released *Made in China 2025*, an update to its state-led industrial policy. The plan was designed to guide and expedite China's evolution into a high-technology manufacturing superpower and global innovation hub. While China may not execute and achieve all of the plan's specific goals (e.g., complete self-sufficiency in all high-technology industries by 2049), the initiative calls for China to create champion firms in the 10 most important industries of the future global economy, including new energy vehicles powered by advanced fuels, supercomputing, and artificial intelligence.[10]

Perhaps no industry will be more important to the country's future ambitions than the automotive sector, which Beijing expects will catalyze prosperity in many other strategic high-technology industries.[11]

Developing a globally competitive automotive industry provides significant economy-wide benefits because it requires large-scale component manufacturing facilities, utilization of a wide array of raw materials and other services, investment in research and development, and support for both direct and indirect jobs. For example,

4 See, e.g., Prasad, Eswar, *China's Growth and Integration into the World Economy: Prospects and Challenges*, International Monetary Fund, 2004.
5 Council on Foreign Relations, "What Happened When China Joined the WTO?" World 101, 2017.
6 U.S. Census Bureau, "Trade in Goods with China," U.S. International Trade Data.
7 See, e.g., Tom Hancock, "Xi Jinping's China: Why Entrepreneurs Feel like Second-Class Citizens," Financial Times, May 13, 2019.
8 United States Trade Representative, *Findings of The Investigation into China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation Under Section 301 of the Trade Act Of 1974*, March 22, 2018 at pages 48-51, 55, and 151
9 China Power Team, "Will China ever be on the cutting edge of global innovation?" China Power Project, August 10, 2017.
10 China Government Website, "Notice of the State Council on Printing and Distributing Made in China 2025," State Council, May 8, 2015, available at: http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm.
11 Jost Wübbeke, Mirjam Meissner, Max J. Zenglein, Jaqueline Ives, and Björn Conrad, "Made in China 2025: The making of a high-tech superpower and consequences for industrial countries," Mercator Institute for China Studies, December 2016, at page 30.

automakers are among the largest purchasers of commodities such as aluminum, copper, plastics, rubber, steel, and computer chips, all of which support other major domestic industries.[12]

China has watched countries, such as the United States, benefit greatly from developing a successful automotive industry. In the United States, the industry supports nearly 10 million jobs, dispersed across the country, with at least 100,000 jobs in 24 different states.[13] Due to the fact that vehicles increasingly integrate software and advanced hardware, the industry will continue to spur innovation in a number of fields.

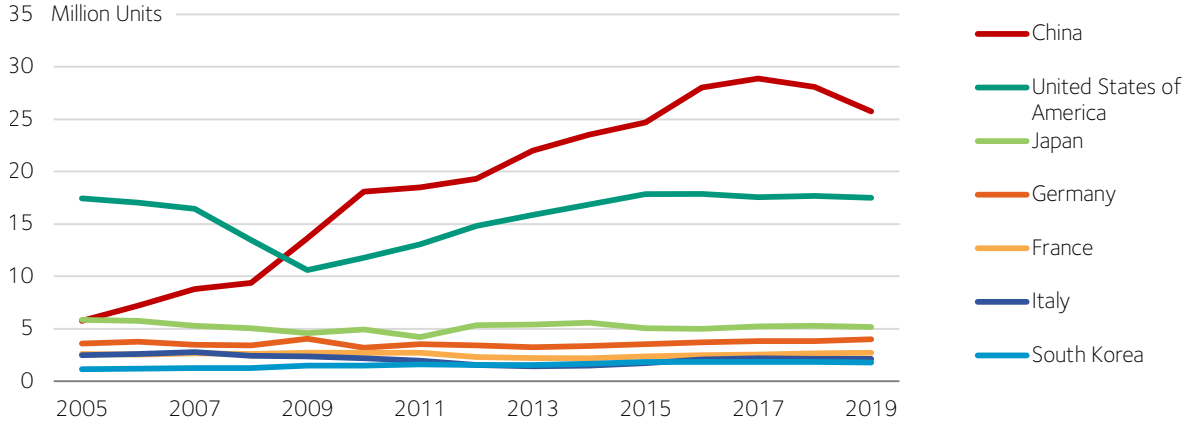
The sheer size of a globally competitive automotive manufacturing sector also conveys other important advantages. During World War II, U.S. auto and transportation companies became the "Arsenal for Democracy," repurposing their people, plants, and manufacturing processes to build tanks, bombers, and trucks at unprecedented scale. Those same companies were recently deployed as an "Arsenal for Health" to combat COVID-19 by making ventilators and other medical equipment, reflecting the industry's sophistication and skill.[14] The United States cannot afford to lose the manufacturing capacity—people, equipment, and management and organizational skills—of a vibrant and healthy automotive industry.

Many of the world's other advanced economies, such as Germany, Japan, and more recently South Korea, have built modernized industrial economies on the sector—a model China hopes to emulate. China's automobile market was virtually nonexistent until the early 1990s but surpassed the United States in 2009 to become the world's largest.[15] To meet demand, China has relied on global automakers to help supply its market—and those automakers have similarly relied on the Chinese market, which is seen as a dependable source of growth and profits.[16] For example, General Motors sold more vehicles in China than in the United States every year for the last decade.[17] China's state-owned car companies have also grown significantly in recent years, largely because of foreign direct investment and joint ventures with foreign automakers, which have helped the country develop vehicle manufacturing expertise it would have otherwise been unable to acquire.

Instead of attempting to compete on current internal combustion engine (ICE) technologies, Beijing has charted a different course.[18] Central to its effort is a focus on electric vehicles (EVs), which provide Beijing with an opportunity for leadership in a nascent technology that will gain significant market share over the coming decades. A focus on EVs will also enable China to leverage its strength in consumer electronic products and its supply

FIGURE 1

Vehicle Sales by Selected Countries, 2005 – 2019



Source: International Organization of Motor Vehicle Manufacturers

12 Auto Alliance, "Major Business Customers," Webpage.
13 See, e.g., Auto Alliance, "In Your State," Webpage.
14 See, e.g., Breana Noble and Kalea Hall, "Detroit's auto industry steps up against COVID-19," The Detroit News, April 6, 2020.
15 See, e.g., Yoko Kubota, "China's Auto Market Stumbles After 30-Year Boom," The Wall Street Journal, January 13, 2020.
16 SAFE analysis based on data from International Organization of Motor Vehicle Manufacturers.
17 See, e.g., Michael Wayland, "GM warns of ongoing challenges in China as sales fall 15% in 2019," CNBC, January 7, 2020.
18 The Economist, "China has never mastered internal-combustion engines," January 2, 2020.

chain dominance. Although current EV penetration levels are small, all projections see EVs poised for tremendous growth. The International Energy Agency (IEA) predicts that by 2030, annual global EV sales will reach 23 million vehicles and the global stock will exceed 130 million.[19] By 2040, Bloomberg New Energy Finance (BNEF) foresees the global stock reaching 500 million EVs.[20] Even the Organization of the Petroleum Exporting Countries (OPEC) foresees roughly 320 million EVs on the road by 2040.[21]

Nearly every major automaker is taking transportation electrification seriously, and they are investing heavily in the technology. Across the industry, automakers will invest $300 billion over the next five to 10 years on EV development and production.[22] Tellingly, nearly half of this investment spending will occur in China—an indicator of where the industry believes demand will be.[23] Regardless of political or technological views on EVs, both China and the industry are undeniably declaring a substantial electric future in transportation.

Because electric vehicles are a pillar of China's strategy in the automotive sector, and the global clean energy sector more broadly, China has aggressively pursued critical mineral supplies from across the globe through long-term contracts with mining companies.[24] This ensures that China will have sufficient supplies of minerals and the ability to control a significant portion of the EV battery manufacturing industry.[25]

Beijing also controls the supply chain for rare earth elements such as neodymium, which is necessary for the production of EV motors.[26] Some minerals, such as lithium and cobalt, are required not just for EV batteries but for manufacturing consumer electronics, and for the development of other new technologies.[27] In addition, China has established the most robust minerals processing industry in the world, adding to its potential future geopolitical leverage.[28]

In addition to EVs, autonomous vehicles (AVs) and intelligent transportation systems utilizing 5G telecommunications technology are two other emerging technologies that could radically transform transportation and, in particular, the costs of moving people and goods.

The global leader in these technologies will reap significant economic benefits, and Beijing has prioritized their development.

Google was one of the first notable companies to begin developing AVs in the late 2000s, and its subsidiary Waymo is currently considered by many to have the most advanced technology in the world.[29] But many AV technology companies in the United States have been hampered by the lack of a comprehensive federal policy and regulatory framework, which has led to a patchwork of competing state regulations.

Today, most of China's largest technology corporations are developing AV technology, with significant investment and state support.[30] The country set a national goal that 10 percent of new vehicle sales will be autonomous by 2030.[31] China already possesses a commanding lead in 5G deployment, which may serve as the communications backbone for AVs and internet-connected infrastructure. Currently, only China is capable of supplying all the technology required for a 5G build-out: base stations, antennas, handsets, and complex data center hardware and software.[32] Since 2015, China has deployed 12 connected 5G sites for every one site

19 IEA, *Global EV Outlook 2019*, May 2019.
20 Bloomberg New Energy Finance, *Electric Vehicle Outlook*, 2019.
21 Organization of the Petroleum Exporting Countries, *2019 OPEC World Oil Outlook*, November 2019, at page 73.
22 Paul Lienert, Norihiko Shirouzu, and Edward Taylor, "Exclusive: VW, China spearhead $300 billion global drive to electrify cars," Reuters, January 10, 2019.
23 Ibid.
24 Marc Humphries, *China's Mineral Industry and U.S. Access to Strategic and Critical Minerals: Issues for Congress*, Congressional Research Service, March 20, 2015, at page 8.
25 FP Analytics, "Mining the Future," Foreign Policy, May 2019, at page 10.
26 Cindy Hurst, "China's Rare Earth Elements Industry: What Can the West Learn?" Institute for the Analysis of Global Security, at page 20.
27 Marc Humphries, *China's Mineral Industry and U.S. Access to Strategic and Critical Minerals: Issues for Congress*, Congressional Research Service, March 20, 2015, at page 5.
28 Keith Johnson and Elias Groll, "China Raises Threat of Rare-Earths Cutoff to U.S.," Foreign Policy, May 21, 2019.
29 See, e.g., Audrey, LaForest, "Groups Call on U.S. Lawmakers to Develop 'Meaningful Legislation' for AVs," Automotive News, February 11, 2020.
30 Rebecca, Fannin, "Needed: A U.S. Response to The Tech Titans in China." Forbes, September 26, 2019.
31 See, e.g., Yan Zhang, "China is way behind the U.S. in driverless vehicles. It's determined to catch up," Los Angeles Times, May 16, 2019.
32 Scott Kennedy, *China's Uneven High-Tech Drive*, Center for Strategic and International Studies, February 2020, at 23.

in the United States.[33] However, because neither of these technologies are yet fully commercialized, there is ample opportunity for either the United States or China to secure a commanding lead.

In certain industries, China's ambitions are unlikely to be realized and pose little threat to American national interests, and U.S. policymakers should consider fostering a mutually beneficial relationship whenever possible. However, if Beijing continues to play by its own rules to gain a competitive edge in industries of national importance or vital supply chains, U.S. policymakers must act with an appropriately calibrated response.

China's Strategy for the Future of Transportation

While both automakers and technology developers continue to signal that transportation will change dramatically over the next decade, Beijing is looking to accelerate that progress by aggressively pursuing emerging transportation technologies, which will yield it important domestic and geopolitical benefits.

In short, China's strategy has three main components: (1) develop a globally competitive electric vehicle industry to end America's stranglehold on oil supplies to China; (2) solidify control of the global critical minerals and EV supply chains; and (3) invest in autonomous and connected vehicle technologies built on a 5G network. There is compelling evidence that all three components are already succeeding.

1. Developing a Competitive EV Industry to End America's Stranglehold on Oil Supplies to China

China faces immense challenges due to its dependence on oil. It consumes more than 13 million barrels of oil per day (Mbd) and is the world's second largest consumer.[34] China's demand for oil, and resulting emissions from motor vehicles, has contributed significantly to air quality issues in its densely populated cities.[35] In addition, China imports more than 10 Mbd, representing more than 70 percent of the country's total consumption.[36] Even low levels of economic growth will spur oil demand growth in China, because of increasing consumer demand for mobility.

As the world's largest importer of oil, China relies heavily on unstable and unpredictable regimes in the Middle East and West Africa, as well as Russia, for those supplies.[37] In addition, the United States remains unparalleled in its ability to project force and control over the sea lanes on which oil traverses, including the Strait of Malacca—representing a significant strategic vulnerability if tensions between China and the United States continue to increase. Such reliance also leaves China's economy vulnerable to disruptions in the world oil market.

By committing to electrify its vehicle fleet, Chinese leaders saw a strategic opportunity to insulate China's economy from the vulnerabilities it experiences as a result of its reliance on oil, ameliorate local environmental conditions, and provide leadership in the auto industry by leapfrogging traditional internal combustion engine technologies as the world looks for cleaner solutions. From 2009 to 2017, China invested nearly $60 billion into its EV industry.[38]

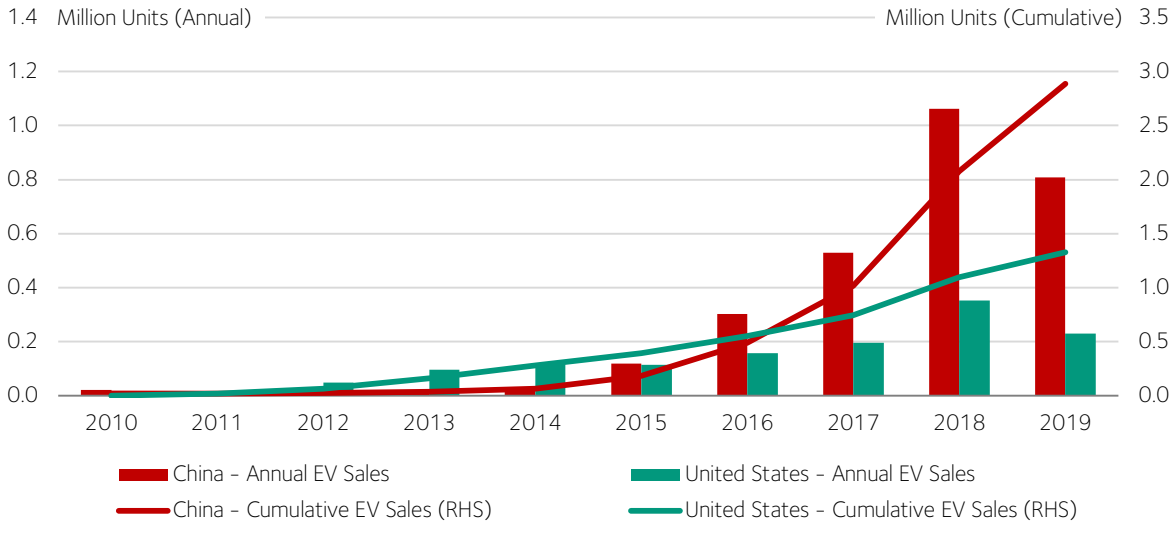
By 2018, there were more than 5 million EVs on the road worldwide, of which approximately 1.1 million were in the United States, and 2.3 million were in China.[39]

China's EV market has been supported by generous government policies to accelerate EV adoption, which include subsidies to manufacturers, sales tax exemptions, priority vehicle registration, manufacturer quotas, and the restriction of investments in new internal combustion engine manufacturing plants. The IEA expects China to maintain its leadership in the global EV market, with a 57 percent market share in 2030.[40]

Beijing has not hesitated to leverage its massive market to benefit its domestic industries. Since the 1990s, Beijing has restricted market access to most foreign automakers unless a joint venture was formed with a Chinese manufacturer—and foreign automakers could own no more than 50 percent of

33 See, e.g., Dan Littmann, *5G: The Chance to Lead for a Decade*, Deloitte, August 2018; and Accenture Inc., "Impact of Federal Regulatory Reviews on Small Cell Deployment", March 12, 2018.
34 EIA, *What Countries Are the Top Producers and Consumers of Oil?*, Frequently Asked Questions (FAQs), April 1, 2020.
35 See, e.g., Jin Wang et al., "Vehicle Emission and Atmospheric Pollution in China: Problems, Progress, and Prospects," PeerJ Journal, May 16, 2019.
36 Jeff Barron, "China's crude oil imports surpassed 10 million barrels per day in 2019," EIA, March 23, 2020.
37 China Power Team, "How is China's energy footprint changing?" China Power Project, 2020.
38 Scott Kennedy and Mingda Qui, "China's Expensive Gamble on New-Energy Vehicles," Center for Strategic and International Studies, November 6, 2018; and IEA, *Global EV Outlook 2019*, IEA.
39 IEA, *Global EV Outlook 2019*, IEA.
40 Scott Kennedy and Mingda Qui, "China's Expensive Gamble on New-Energy Vehicles," Center for Strategic and International Studies, November 6, 2018; and IEA, *Global EV Outlook 2019*, IEA.

FIGURE 2
U.S. and China Electric Vehicle Sales, 2010 – 2019



Note: SAFE analysis based on data from Bloomberg.

the partnership.[41] Beijing uses these joint ventures to coerce technology transfer and accelerate its domestic companies' progress. In 2018, as part of a concession to the United States over trade tensions, Beijing announced that it will phase out these restrictions over the next several years. While market observers believe this is a positive step toward fairer competition, nearly every major automaker has already developed a joint venture in China, which as of 2018 had an average remaining contract term of more than 15 years.[42] The presence of existing contracts means China has likely forced most global automakers to share profits and technology with their joint venture partner for the next decade or longer.[43]

Nevertheless, the change in policy signals that Beijing is confident that its companies will soon be able to compete with the largest auto manufacturers in the world outside of China.

2. Solidifying Global Control of Critical Minerals and EV Supply Chains

As stated in its *Made in China 2025* plan, China has ambitions of becoming a top tier economy. To accomplish this, China must move up the manufacturing value chain and demonstrate that it has developed a level of manufacturing sophistication other advanced economies already possess. By producing globally competitive vehicles and other automotive components, China can move toward parity with the most advanced economies in the world.

EVs are an easier technology to manufacture than internal combustion engines because they have fewer moving parts. For example, conventional drivetrains have as many as 2,000 components, while drivetrains for electric vehicles may have as few as 20.[44] This provides China an opportunity to realize its ambitions more expeditiously in a foundational industrial sector.

While developing complex high-value products is one desired outcome, Beijing also recognizes the value of managing logistics and supply chains for goods. As the COVID-19 pandemic reminded the world, many countries rely on China for deliveries of active pharmaceutical

41 See, e.g., Norihiko Shirouzu and Adam Jourdan, "China to Open Auto Market as Trade Tensions Simmer," Reuters, April 17, 2018.
42 Mark Schaub and Atticus Zhao, "Impact of China Removal of Restrictions in Auto Sector," King and Wood Mallesons, July 24, 2018.
43 Patrick E. Mears and Eric Wang, "The Use of Equity Joint Ventures with China's Automotive Industry," LexisNexis Emerging Issues Analysis, September 2016; and Note: In 2018, China agreed to provide market access to Tesla without the requirement of a joint venture. That announcement coincided with a statement between the two parties that Tesla would cooperate on a research and design center.
44 See, e.g., Ian Thibodeau, "Shift to electric vehicles will radically change auto factories," The Detroit News, September 5, 2019.

ingredients, and for personal protective equipment.[45]

Beijing's control of supply chains—which provides it tremendous geopolitical leverage—is playing out similarly in the transportation sphere. Securing mineral supply chains is crucial because their applications are important to EVs, future energy needs like battery storage, and weapon systems.

Four minerals—cobalt, lithium, graphite and nickel—are vital for EV battery production. Two rare earth elements, neodymium and dysprosium, are necessary for the magnets in the electric motors, while copper and aluminum are important for the entire vehicle. Beijing understands the potential vulnerability an inability to source critical minerals poses to its broader goals, and it has worked to avert this possibility. In addition, by controlling or significantly influencing critical minerals markets, Beijing may be able to deny competitors access, and extract meaningful concessions in trade or political negotiations with other countries.

A meaningful percentage of the production cost of an EV battery comes from the cost of minerals, especially nickel, cobalt, and lithium.[46] Although countries and companies are looking to develop new battery chemistries or substitutes for materials such as cobalt, those three minerals remain in high demand. Beijing, for example, has focused on developing alternatives to the widely used nickel-cobalt-manganese (NCM) or nickel-cobalt-aluminum (NCA) cathodes. China's top battery maker, CATL, has prioritized lithium-iron-phosphate (LFP) cathodes that contain no cobalt, and have signed an agreement to provide batteries for Tesla vehicles made in China.[47] While supply of and demand for minerals will continue to fluctuate, Beijing knows that the global economy has become much more reliant on a number of critical minerals, and has moved swiftly to secure those resources when others have not.

As a result, China controls more critical mineral reserves and companies than any other country, and it has developed the largest minerals processing industry in the world.[48] For example, in 2018 China's Tianqi Lithium acquired a 32 percent stake in Chile's Sociedad Quimica y Minera SA, helping China consolidate its influence over approximately 70 percent of the global lithium supply.[49] In the Democratic Republic of Congo, the source of more than two-thirds of global cobalt production, eight of the largest 14 mines are Chinese-owned.[50]

Chinese companies also mine and process minerals with less regard for worker or environmental safety.[51] Downplaying the environmental impacts ensures that it is more difficult for other countries to compete on cost, particularly when they depend on private capital and markets to build and operate mines and processing facilities. Beijing has estimated that it would cost $5.5 billion to remediate environmental damage from mining operations in one province alone.[52]

Regarding EV battery production, China has concretized its lead over the last several years. In May 2020, there were at least 142 lithium-ion battery megafactories under construction across four continents, 107 of which are, or will be, located in China.[53] Only nine are currently planned for the United States.[54]

As China moves first to build EV battery plants, through generous state support, it is altering the competitive landscape and making it more difficult for the United States and other countries to compete.

China's dominance of these important supply chains also provides it a significant advantage when developing other essential automotive components that will be used in future transportation technologies. For example, Beijing's control of the global rare earth elements processing industry has helped it become the world's largest producer of permanent magnets—which are also used in the latest phones, computers, and EV motors.[55] Magnets as a whole currently account for more than 25 percent of global rare earth elements consumption. As the EV industry grows, so will China's leverage over the magnet industry.[56]

45 See, e.g., Keith Bradsher, "Coronavirus Battle Creates a Global 'Free-for-All' to Find Masks," The New York Times, April 1, 2020; and Priyali Sur, "The coronavirus exposed the US' reliance on India for generic drugs. But that supply chain is ultimately controlled by China," CNN, May 16, 2020.

46 See, e.g., Simon Moores, "Written Testimony of Simon Moores: Outlook for energy and minerals markets in the 116th Congress," Benchmark Mineral Intelligence and U.S. Senate Committee on Energy and Natural Resources, February 5, 2019.

47 Zhang Yan, Yilei Sun, and Brenda Goh, "Tesla in talks to use CATL's cobalt-free batteries in China-made cars – sources," Reuters, February 18, 2020.

48 See, e.g. Andrea Shalal, "Explainer: China's Rare Earth Supplies Could Be Vital Bargaining Chip in U.S. Trade War," Reuters, May 30, 2019.

49 See, e.g., Allison Prang, "Tianqi Lithium to Buy Minority Stake in Miner SQM for $4.07 Billion," The Wall Street Journal, May 17, 2018.

50 See, e.g., Jack Farchy and Hayley Warren, "China Has a Secret Weapon in the Race to Dominate Electric Cars," Bloomberg, December 2, 2018.

51 See, e.g., Jonathan Kaiman, "Rare Earth Mining in China: the Bleak Social and Environmental Costs," The Guardian, March 20, 2014.

52 See, e.g., Alice Su, "The Hidden Costs of China's Rare-Earth Trade," Los Angeles Times, July 29, 2019.

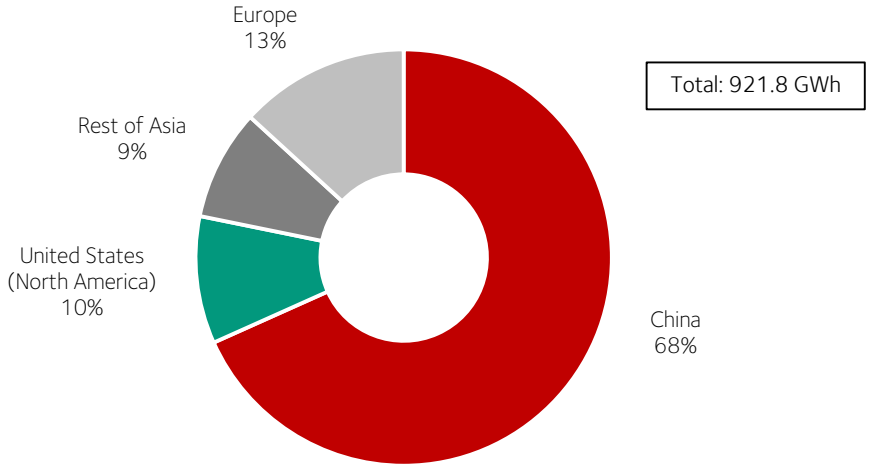
53 Simon Moores, "Written Testimony of Simon Moores: Full Committee Hearing on the Impact of COVID-19 on Mineral Supply Chains," Benchmark Mineral Intelligence and U.S. Senate Committee on Energy and Natural Resources, June 24, 2020.

54 Ibid.

55 See, e.g., Winnie Zhu, "Chinese Rare-Earth Magnet Producer to Expand as EV Demand Booms," Bloomberg News, June 23, 2019.

56 Ibid.

FIGURE 3
Forecast Battery Megafactory Capacity by Region, 2023



Note: Benchmark Mineral Intelligence

3. Investing in Autonomous and Connected Vehicle Technologies Built on a 5G Network

The Chinese Communist Party (CCP) continues to prioritize maintaining strict control over Chinese citizens, and is leveraging 5G technology to do so. Beijing is becoming a surveillance state. It has already built a comprehensive electronic surveillance network, which tracks Chinese citizens using security cameras, telecommunications data, and artificial intelligence.[57] Critically, the decisions that Beijing makes for domestic reasons have grave implications for the rest of the world. This could not be made clearer than through the deployment of 5G telecommunications networks, which will support future transportation technologies such as autonomous and connected vehicles. Deploying autonomous and connected vehicles over a 5G network will help the CCP more precisely track and monitor travel movements of individual citizens, and collect additional data. However, if China begins manufacturing automobiles for export to other countries, Beijing may develop the ability to similarly track the movements of foreign citizens globally and use that information to gather political or economic intelligence.

Beijing has thus far focused on building out the city-level infrastructure to support autonomous vehicles, but it is increasingly signaling its desire to become a global leader in AV technology. China's search engine giant Baidu began AV testing in 2017 and announced last year that its fleet of 300 AVs had amassed more than 1.2 million miles driving in 13 Chinese cities (Waymo has driven more than 20 million miles since 2009).[58] China's telecommunications giant, Huawei Technologies Co., has already developed its own chips for autonomous driving and is collaborating with companies such as Toyota and Audi.[59] Similar to the United States, China has developed national guidelines for AVs and has created dedicated facilities and roads to test them.

China has also prioritized the development of its semiconductor industry, and has allegedly stolen intellectual property for lidar technology.[60] Both semiconductors and lidar technology may be necessary for the commercialization of autonomous vehicles. In the semiconductor supply chain, China has previously focused on lower-value activities like assembly, testing, and packaging. However, to reduce its reliance on the United States, Beijing is planning to invest more than $118 billion over five years to develop its semiconductor industry and move toward the higher-value activities such as design and research.[61] There are significant implications for the United States if China succeeds.

57 See, e.g., Yingzhi Yang and Julie Zhu, "Coronavirus brings China's surveillance state out of the shadows," Reuters, February 7, 2020.

58 See, e.g., Kyle Wiggers, "Baidu's Autonomous Cars Have Driven More than 1 Million Miles across 13 Cities in China," VentureBeat, July 2, 2019; and Kyle Wiggers, "Waymo's Autonomous Cars Have Driven 20 Million Miles on Public Roads," VentureBeat, January 6, 2020.

59 See, e.g., Cheng Ting-Fang and Lauly Li, "Huawei steps up ambitions in self-driving vehicles race," Nikkei Asian Review, March 30, 2020.

60 Echo Huang, "The World's leader in self-driving lidar technology is suing two Chinese companies over IP," Quartz, August 15, 2019.

61 James Lewis, *Learning the Superior Techniques of the Barbarians*, Center for Strategic and International Studies, January 2019.

China's government and its telecommunications firms are also aggressively pursuing the economic gains associated with 5G—which is expected to offer 100-times faster speeds than the current telecommunications network.[62] Beijing has identified 5G network development as a national priority.[63] Unlike in the United States, where mobile phone carriers competitively invest in new technological capabilities according to market signals and scale, Beijing's approach is top-down: the government's plan pledges more than $400 billion in 5G research and development through 2020.[64] In 2018, China completed the first phase of its 5G trials and is now working toward commercialization.[65] The scale of China's investment is far larger than the United States; China has installed at least 350,000 5G sites, compared to fewer than 30,000 in the United States.[66]

Through Huawei, China is taking a leading role in issuing patents, identifying industrial use cases, and informing global equipment standards for 5G. Moreover, Huawei is on pace to gain a substantial portion of the worldwide 5G market, having won at least 90 international contracts for its software, equipment, and services.[67] China's advanced technology and well-financed deployment strategy has alarmed the U.S. intelligence community—largely because of Beijing's potential to track individual citizens. As a result, regulators in the United States have severely restricted the use of Huawei's technology, citing intelligence community concerns about cyber espionage vulnerabilities. Despite protests from the United States, many U.S. allies have declined to take similar steps.[68]

The automotive industry of the future can help expand research and development, and high-technology manufacturing, in the United States. However, maintaining the status quo is not sufficient to guard against the threats arising from China's broader ambitions in the automotive market.

62 Ericsson Inc., *Ericsson Mobility Report*, November 2018, at page 6; and Gopal Ratnam, "5G Technologies Could Challenge US Spy Agencies," Roll Call, February 26, 2019; and Lindsay Gorman, "5G Is Where China and the West Finally Diverge," The Atlantic, January 5, 2020.

63 Central Committee of the Communist Party of China, The 13th Five-Year Plan for Economic and Social Development of the Peoples' Republic of China 2016-2020, 2015.

64 See, e.g., Dan Littmann et al., *5G: The Chance to Lead for a Decade*, Deloitte, 2018, at page 1; and Susan Crawford, "China Will Likely Corner the 5G Market – and the U.S. Has No Plan," Wired, February 2, 2019; and Silvia Amaro, "China is vastly outspending the US on 5G infrastructure, expert says," CNBC, November 18, 2019.

65 Huawei Technologies Co. Ltd., "Huawei Takes the Lead in Completing China 5G Technology R&D Trial using 2.6GHz Spectrum," Press Release, January 17, 2019; and Juan Pedro Tomas, "Huawei completes third phase of China's national 5G trial," RCR Wireless News, January 21, 2019.

66 See, Dan Littmann et al., *5G: The Chance to Lead for a Decade*, Deloitte, 2018, at page 1; and Accenture Strategy and Accenture Network Practice, *Impact of Federal Regulatory Reviews on Small Cell Deployment*, Accenture, March 12, 2018.

67 Lauly Li and Cheng Ting-Fang, "Huawei claims over 90 contracts for 5G, leading Ericsson," Nikkei Asian Review, February 21, 2020.

68 See, e.g., Luke Baker and John Chalmers, "As Britain bans Huawei, U.S. pressure mounts on Europe to follow suit," Reuters, July 14, 2020.

America's Challenge: Preserving Technological Superiority in the Transportation Sector

China has unambiguously identified its national priorities in the transportation sector, which, if executed successfully, will present significant challenges to the United States. Confronting those challenges will not be easy. It will first require an honest assessment by policymakers of the risks to U.S. economic and national security. In the best case, this risk amounts to a significant loss of jobs as the United States cedes some advanced technology and automobile manufacturing to China. At worst, it amounts to a severe degradation of the U.S.-based innovation ecosystem—a system which catalyzes future economic growth and enables the United States to stay ahead in the technological, industrial, and military competition. Fortunately, there is a clear solution that will allow the United States to diminish the threats China poses to America's transportation industrial base and technology leadership, while also achieving long-standing energy security goals.

To remain competitive on the global stage, the United States must transition its transportation system away from a heavy reliance on oil toward a more diverse mix of fuels, which do not expose the broader economy to the volatility of global oil markets. Advanced fuel vehicles (AFVs) powered by non-petroleum American energy sources such as electricity, natural gas, and hydrogen are perhaps the only way to create durable change. By prioritizing fuel diversity through greater adoption of AFVs, the United States will be better positioned to compete with China. If China successfully transitions away from oil, while the United States does not, America will be at a disadvantage economically when the global oil market inevitably experiences a severe price spike. Over the last several decades, the United States has spent trillions of dollars engaging in numerous conflicts in the Middle East, in large part, because of oil. If dependence on oil causes the United States to continue spending to protect oil supplies while China is less exposed to the effects of global conflicts and market disruptions, it will make it more difficult for the United States to compete in the global economy.

The U.S. transportation sector consumes more than 14 Mbd, a volume that exceeds the total oil consumption of every other nation in the world.[69]

69 EIA, "Oil: crude and petroleum products explained," October 3, 2019.

Petroleum fuels account for roughly 92 percent of the energy consumed in transportation—a share essentially unchanged since the advent of the automobile.[70]

While oil has facilitated the rise of the modern era, reliance on it has created tremendous vulnerabilities. So long as the cars and trucks that power our economy depend on a single fuel source, the U.S. economy will be at the mercy of events and actors largely beyond its control. Robust domestic liquid fuels production could reduce some of the negative consequences. However, energy security remains largely a function of consumption of a fuel from unstable regions, traded on a manipulated market, and controlled by countries that do not share our interests.

China is building toward a transportation future that integrates EV, AV, and 5G technologies, and is using a whole-of-nation approach to outmaneuver competitors. Unfortunately, U.S. policymakers have been slow to respond, and may not yet comprehend what a global automotive industry heavily influenced by China truly means.

As noted, China already controls nearly every aspect of the EV battery supply chain, from the mining and processing of critical minerals to the production of lithium-ion battery cells. Beijing controls nearly 70 percent of global EV battery manufacturing capacity, while North America has less than 10 percent.[71]

China's success in the automotive sector, especially as EVs gain greater market share, puts the United States at a severe competitive disadvantage, and likely means that both new investments and jobs will gravitate toward China instead of the United States.

The U.S. automotive industry plays a critical role in the economic health and prosperity of the country, and it is one of the largest and most important sectors of our manufacturing economy. Thirteen automakers operate 44 assembly plants across 14 states, and the industry has invested $46 billion in U.S. factories and facilities between 2010 and 2014.[72] In early 2020, before coronavirus hit, there were close to one million people directly employed in vehicle and parts manufacturing—and at an average hourly wage of more than $23, those jobs pay more than most other manufacturing jobs.[73] When additional jobs, such as those at dealerships are included, the industry supports nearly 10 million jobs, representing more than 5 percent of all private sector employment.[74]

Additionally, China's control of critical minerals may also threaten the U.S. defense industrial base if the U.S. Department of Defense is unable to secure the materials it needs to manufacture weapons systems and advanced electronic components.[75] Last year, in response to China's global control of critical minerals and rare earth elements, the U.S. Army began planning the construction of a domestic rare earths processing facility, and issued a request for proposals to build a pilot plant for the production of heavy rare earths.[76]

Recommended U.S. Strategy to Maintain U.S. Competitiveness

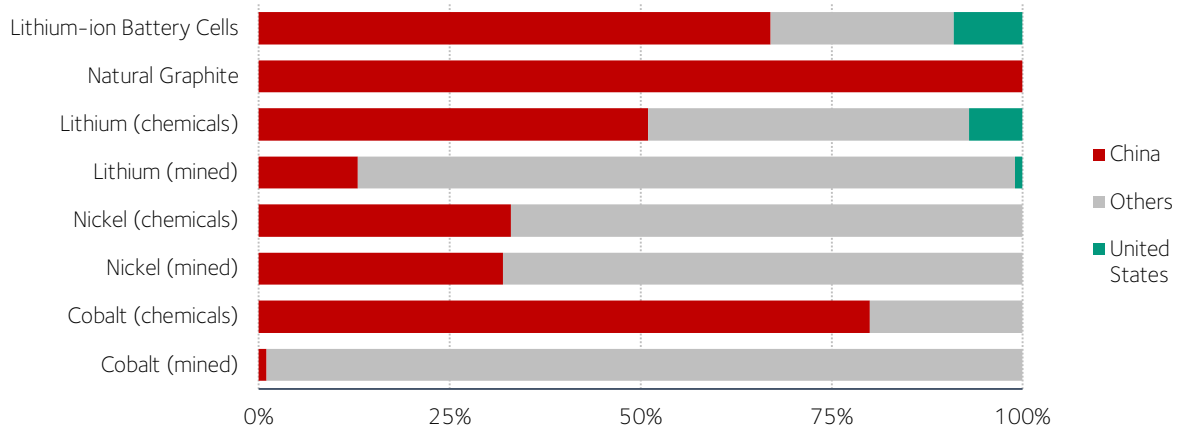
The automotive industry is evolving rapidly to a connected, autonomous, and electric transportation future. Ideally, the deployment of these technologies would emerge through regular market mechanisms and fair competition. But given the importance of the automotive industry to our economy, and the implications for the United States if China controls the commanding heights of global transportation, engagement by the U.S. government is warranted. The United States urgently needs a comprehensive strategy to combat the risks posed by China's ambitions in the automotive sector—from minerals to markets.

1. Develop a Critical Minerals Supply Chain That is Not Controlled by China

Critical minerals are the building blocks used to develop still unimagined technologies and, as EVs proliferate, America must avoid trading dependence on oil for dependence on minerals controlled by China. The federal government must find ways to reclaim parts of critical mineral

70 EIA, "U.S. energy facts explained," June 2, 2020.
71 Benchmark Mineral Intelligence, "Lithium-Ion Battery Megafactory Assessment," February 2020.
72 Auto Alliance, *Cars Move America: State of the Auto Industry*, 2016, at page 7; and U.S. Bureau of Labor Statistics, "Automotive Industry: Employment, Earnings, and Hours," March 2020.
73 U.S. Bureau of Labor Statistics, "Automotive Industry: Employment, Earnings, and Hours," June 19, 2020.
74 Ibid.
75 See, e.g., Jeffery Green, "What will the US defense industry do when China cuts off rare earth supplies?," DefenseNews, July 5, 2019.
76 Ernest Scheyder, "Exclusive: U.S. Army will fund rare earths plant for weapons development," Reuters, December 11, 2019.

FIGURE 4
Global Share of Battery Supply Chain



Source: Benchmark Mineral Intelligence, Bloomberg News

supply chains controlled by China. These approaches include domestic mineral mining and developing mineral refining and processing facilities in the United States. Such approaches should consider how best to utilize our domestic resources and modernize our nation's mineral permitting system without sacrificing fundamental environmental safeguards.

In addition, our allies hold vast mineral reserves, and we must convince them to deny Chinese expansion of its already substantial control of critical mineral supplies. The federal government should also support R&D to create viable substitute materials for any critical minerals that may face supply shortages in the future.

2. Support the Advanced Fuel Vehicle Market and Domestic Manufacturing

U.S. policymakers should explore approaches that support the development and deployment of new transportation technologies. This will be achieved through fuel-neutral policies designed to accelerate adoption of advanced fuel vehicles. Unfortunately, advanced fuel vehicles are often caught in partisan debates between climate change and free markets. It is time to put the interests of the nation first. Regardless of one's views on climate change and the environment, electric vehicles are likely the future of the auto industry—and the United States must lead. Once the industrial base for vehicle manufacturing is lost, the entire ecosystem that evolves around the automotive industry will be lost as well, which will make it nearly impossible for the United States to reclaim the commanding heights.

Policymakers can ensure American companies remain competitive, and keep jobs in the United States, by supporting the market for many of these new technologies. In furtherance of these goals, Congress should support charging or refueling infrastructure and extend and expand federal tax credits for advanced fuel vehicles, including for medium- and heavy-duty vehicles. Congress should also commit to funding research and development for next-generation battery technologies and support the domestic manufacturing of other important component parts such as cathodes and anodes for batteries, and semiconductors. This will likely require tax incentives or grant programs for companies to build component-manufacturing facilities in the United States. The implementation of such policies will help ensure that the U.S. automotive industry is prepared to compete with China for leadership over the next generation of mobility.

3. Advance Next-Generation Transportation Technologies

For the first time in more than a century, the automotive industry has begun to introduce a revolutionary technological advancement that will improve both social and personal utility. Autonomous vehicles and intelligent transportation systems built on a 5G telecommunications network could radically transform everything from the ways we power our vehicles and design our cities to the costs of moving people, goods, and services throughout the economy. Policy must be flexible and nimble to allow the nation to maximize the

benefits of autonomy and 5G networks while minimizing the risks.

To stay ahead of China on technologies such as AVs, Congress should enact a comprehensive federal regulatory framework to expedite the safe development, testing, and deployment of AVs. This framework must preempt the current patchwork of state regulations, which create significant regulatory uncertainty for industry. The federal government should also develop a plan for regulating vehicle efficiency that reflects and facilitates the technological transformation taking place with autonomous and connected vehicles. Concurrently, the federal government should expand its exemptions program to provide a pathway for deploying AVs with novel design configurations — which may enable further innovation in design and business model applications.

4. Combat Predatory Economic Practices

Finally, the government must develop new response mechanisms to combat Beijing's harmful economic and trade practices. U.S. policymakers must actively ensure that Beijing is not allowed to manipulate the rules-based international trade system, and must aggressively defend against trade violations at the WTO. This will be difficult to accomplish in isolation, but by coordinating more closely with like-minded nations the U.S. government can build the necessary alliance to develop a common response regarding China and trade.

Similarly, the federal government should undertake a robust diplomatic campaign to explain to U.S. allies and security partners the serious risks associated with deploying Chinese 5G telecommunications equipment.

The federal government should also examine new methods to better support American companies operating in China, including by developing a coordinating body that represents U.S. automaker interests there, which will help protect American intellectual property and trade secrets.

Bipartisan support will be required to advance a new national agenda that strengthens and revitalizes the nation's automotive sector, which will bolster our economic competitiveness. To facilitate a long-term solution, U.S. policymakers must act now, before we cede leadership over the commanding heights of global transportation.

The Future of Transportation

In 1983, a Chinese and an American company worked together to manufacture a Jeep in Beijing. It started with great promise: news that the American Motors Corporation (AMC) had signed the first automotive joint venture with China hit the front pages of newspapers across America and helped the struggling car company's stock price surge 40 percent.

The joint venture, Beijing Jeep, was the China deal of the 1980s. Vice President George Bush visited the project in China, as did Communist Party General Secretary Zhao Ziyang. It did not, however, end well.

The Chinese and American factory managers argued over everything, from the number of doors the Jeep should have, how much technology to transfer, to whether it was appropriate for Chinese employees to have cots in their offices. The country was still recovering from the chaos of the era of Mao Zedong, who died in 1976. The Cultural Revolution, which ravaged the country for a decade starting in 1966, shut schools, attempted to destroy concepts like 'capitalism' and 'private property,' and led to a severe shortage of trained professionals. The country lacked the talent, experience, regulations, and market to support automotive production. When Beijing Jeep finally assembled a version of the iconic American vehicle in 1985 in China, workers had to push it off the Beijing production line—it was literally undrivable.[77]

Despite the initial failure, American companies remained intent on helping Beijing master automotive production, because they thought it would help them succeed in China's massive market. Beijing was also undeterred, and Chinese companies kept persevering, sometimes ethically, and sometimes not, helped by the heavy hand of Beijing. Over the course of the next several decades, China convinced key American government officials and businesspeople to prioritize the Chinese Communist Party's (CCP) interests, while at the same time shaping the battlefield to Beijing's benefit.

In 1984, China had a population exceeding 1 billion, but only 5,600 privately-owned vehicles, a number far smaller than in even the poorest cities in America today.[78] Now, more than 35 years later, and with more than 300 million vehicles, China stands poised to dominate the future of transportation. That future will be established upon a foundation of autonomous, connected, and electric (ACE) vehicles, and the 5G infrastructure that supports them. The countries that lead this transition will hold significant advantages in the future global economy.

Three factors caused the current state of affairs: Beijing's whole-of-nation approach to transportation technologies, a foreign policy that enabled China to consolidate control of supply chains for critical minerals and other automotive components, and the shortsightedness of American policymakers and corporations.

This is a story about the future of transportation. A story that describes how shifts in U.S. energy policy, and, until recently, an increasingly interdependent relationship with China, helped build a globally competitive Chinese auto sector. What follows articulates China's ambitions in the automotive sector, and the implications of those ambitions for the U.S. economy and industrial base. It then tells how Beijing solidified control of the critical minerals and electric vehicle supply chains, and the new reality that American car companies and technology developers now face. Finally, this is a story about how Beijing could wrest control of the United States' lead in AV technology to complement its advantages in 5G. The report concludes with a suite of policy recommendations that hold the potential to change the direction of the emerging ACE world order and ensure that the United States maintains the commanding heights of global transportation.

77 James Mann, *Beijing Jeep: A Case Study of Western Business in China*, 2019, at pages 25-26, 161, 165.

78 Joe Studwell, *The China Dream: The Quest for the Last Great Untapped Market on Earth*, 2002, at pages 24 and 83.

U.S.-China Political and Energy Relations

At various geopolitical inflection points over the last century, the U.S. government worked to ensure access to a safe and reliable energy supply. The series of shocks and disruption that pervaded global oil markets throughout the 1960s and 1970s left U.S. policymakers acutely aware of the challenges associated with a transportation sector that was dependent on oil.[81]

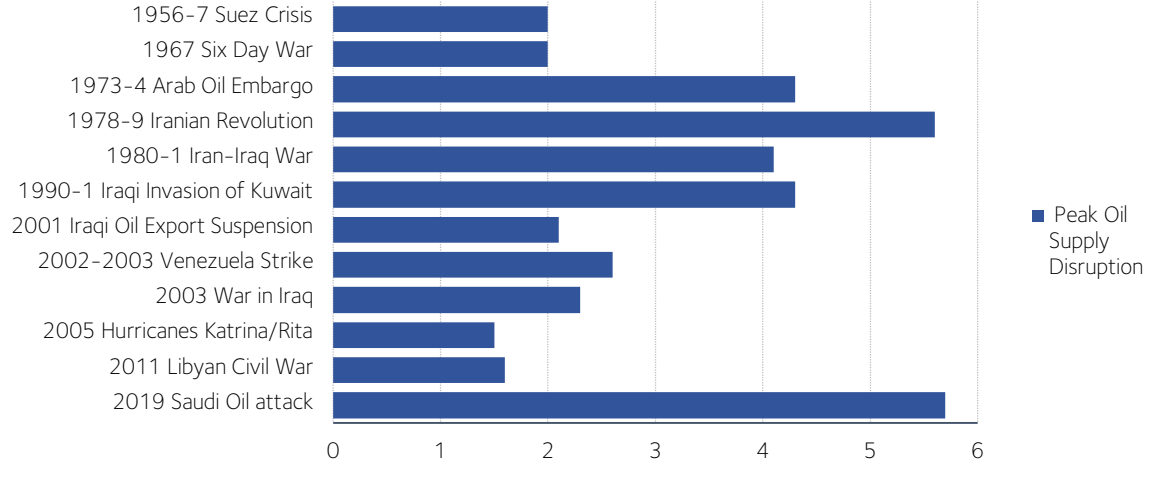
The vast infrastructure investments in the National Highway System by the U.S. government contributed to an increasingly mobile population that was consuming fuel at unprecedented rates.

This growing consumer demand existed independent from the reality that U.S. drillers had little spare production capacity left to continue pumping more oil domestically.[80] In 1950, imported oil met roughly 8 percent of domestic demand.[81] By 1973, imported oil reached roughly 20 percent of consumption, and continued to climb until it reached more than 37 percent by 1980.[82]

As global demand for oil grew in the post-World War II era, major oil producing states in the Middle East and South America formed a cartel called the Organization of the Petroleum Exporting Countries (OPEC) in 1960. The founding goals of OPEC were to exert greater control over oil prices, claim a greater share of revenue, and curb U.S. and European oil companies' influence over the oil market. The potential for OPEC to exert influence, not just in oil

FIGURE 5

Major World Oil Supply Disruptions



Source: IEA and EIA

79 Council on Foreign Relations, "Oil Dependence and U.S. Foreign Policy," 2020.

80 Note: Increased scrutiny of oil production also came in the form of new environmental regulations related to air quality and safety.

81 SAFE analysis based on data from EIA, *Monthly Energy Review*, April 2020.

82 Ibid.

pricing but in larger geopolitical events, became clear during the Six Days and Yom Kippur Wars. OPEC's 1973 U.S. oil embargo, a direct response to the Yom Kippur War, had a profound psychological effect in oil consuming nations, as gasoline prices skyrocketed along with anxiety over oil shortages. In November 1973, President Richard Nixon declared that America was facing an "energy crisis."[83] Shortly after, Nixon announced his ambitious goal to set the United States on a course for energy self-reliance by 1980, calling it "Project Independence."[84]

These crises demonstrated the U.S. vulnerability to a global oil market manipulated by OPEC, which helped frame energy security as a national security issue.

In recognition of the threat oil presented, Congress passed a series of measures intended to help the United States adjust to the new normal: a world where foreign nations could use oil dependence as a geopolitical cudgel against the United States.

Anxiety about and understanding of the strategic importance of oil to the United States laid the seeds for a renewed interest—and greater investment in research and development (R&D)—in advanced fuels and energy solutions, including electric vehicles.[85]

At the outset of the oil crises of the 1960s and 1970s, U.S. automotive manufacturers, like General Motors (GM) and the auto giant American Motor Company (AMC), which Chrysler acquired in 1987, took notice and began working on developing EVs and other advanced fuel vehicles.[86] EVs were seen as an attractive solution that could reduce U.S. reliance on oil by drawing energy from the electrical grid's existing generation, transmission, and distribution infrastructure. This electricity was, and still is today, generated from a stable and diverse portfolio of largely domestic fuels, including coal, natural gas, nuclear, and renewables.

The government also implemented a series of legislative measures intended to bolster U.S. energy security. It established the Strategic Petroleum Reserve, and mandated new speed limits and fuel efficiency standards.[87] It also passed the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, empowering the Department of Energy—created by President Jimmy Carter the following year—to devote more time and resources into electric and hybrid vehicle technology.[88] While these early-stage EV projects suffered from performance shortcomings, they laid the groundwork for future government efforts on transportation electrification.

Nixon to China

It was only after Richard Nixon's groundbreaking 1972 trip to Beijing that China's potential as a U.S. energy ally appeared on Washington's radar. Following that trip, U.S. energy officials and oil companies became increasingly interested in the presumed vastness of China's untapped oil reserves.[89] In the late 1970s and early 1980s, foreign oil companies spent an estimated $200 million on an extensive seismic survey, which produced data that Beijing demanded oil companies provide as a show of goodwill.[90] The disappointment of the resulting data and the expense of operating in China frustrated most oil companies' dreams of flourishing there in the near term. Nevertheless, the 1979 Iranian revolution, and the oil supply disruption that followed, only helped reinforce to U.S. policymakers the importance of diversifying from reliance on the greater Middle East region for oil.

Foreign interest in the broader Chinese market declined after the June 1989 massacre in Tiananmen Square, where Chinese soldiers opened fire on unarmed protestors.[91] However, interest soon recovered—and then surpassed the excitement felt in the 1980s. As China's economy began to surge, with GDP growing more than 14 percent in 1992 and 1993, U.S. business interests and policymakers sought a way to convince the American people to support trade with China—despite the image of the Tiananmen bloodshed fresh in voters' minds.[92]

The answer U.S. policymakers decided upon had major implications for all sectors of the U.S. economy, including transportation and energy, and still influences those sectors' relationship with China today. Free trade with

83 See, e.g., Transcript of Nixon's Address, The New York Times Archives, November 26, 1973.
84 Ibid.
85 See, e.g., Rebecca Matulka, "The History of the Electric Car," U.S. Department of Energy, September 15, 2014.
86 Ibid.
87 Office of Energy Policy and Systems Analysis, "Valuation of Energy Security for the United States: Report to Congress," U.S. Department of Energy, January 2017, at pages 18, 42-43, and 67.
88 See, e.g., U.S. Department of Energy, "Hydrogen & Fuel Cells Program," Webpage.
89 Joe Studwell, *The China Dream: The Quest for the Last Great Untapped Market on Earth*," 2002, at pages 22-23
90 Randall Stross, *Bulls in the China Shop, and Other Sino-American Business Encounters*, 1990, at 61-62.
91 Harry Harding, "The Impact of Tiananmen on China's Foreign Policy," The National Bureau of Asian Research, December 1, 1990.
92 World Bank, "GDP Growth (annual %) – China," Webpage, 2019.

China via preferential policies and permission to enter the World Trade Organization (WTO), policymakers said, would liberalize China. It would bring democracy, a free press, and human rights to the world's largest and—after the 1991 collapse of the Soviet Union—most powerful Communist country.

The corollary was that American companies, the U.S. government, and non-governmental organizations should enrich China: doing so would both democratize China and bring wealth and jobs to Americans. It was a bipartisan effort, convincing Americans that helping China's economy was a classic case of doing well by doing good.[93] The George H.W. Bush administration articulated a vision that economic liberalization in China would ultimately lead to political liberalization.[94] President Bill Clinton made a similar argument for why China should join the WTO.[95] The efforts culminated in China's 2001 accession to the WTO, which was the same year that President George W. Bush granted permanent normal trading relations (PNTR) status to China.[96] Both of these actions contributed to the sense among many corporations that China was the most exciting market for both sales and manufacturing.

A Rising China and A Troubled U.S. Automotive Sector

After 9/11, amidst greater corporate access to the Chinese market, the George W. Bush administration prioritized partnering with China in the global fight against terrorism. This happened despite China's theft of American corporate intellectual property (IP) and its widespread human rights violations. Starting in 2003 and continuing for at least three years, Chinese hackers breached Lockheed Martin, NASA, and the U.S. Redstone Arsenal military base, among others, in an in incident known as Titan Rain.[97] In 2004, there were 74,000 protests in China against issues like injustice, corruption, and forcible land seizure, and in 2005, Beijing sentenced the journalist Shi Tao to trumped-up charges of "leaking state secrets abroad."[98]

By 2005, policymakers and American companies grew increasingly worried about unfair Chinese economic practices.

In September of that year, Deputy Secretary of State Bob Zoellick gave an important speech, *Whither China: From Member to Responsibility?*, which reflected shifting policy priorities. Zoellick explained that the U.S. policy of encouraging Chinese economic development had succeeded, but it was now necessary to encourage Beijing to be a responsible stakeholder in the world order the United States had helped create.[99] That functioned as the Bush administration's policy for the last several years of his presidency.

The Bush administration also began raising the alarm about the controversial telecommunications equipment giant Huawei, which today is arguably the most important player in the 5G space. Founded in 1987, Huawei has always claimed to be a private company, though Beijing's support helped it become dominant, and it often functions as a de facto arm of the state.[100] In 2007, the Bush administration prevented a deal between Huawei and Bain Capital to purchase the American network equipment maker, 3Com, because the latter made software for the U.S. military.[101]

Perhaps President Barack Obama might have prioritized confronting Beijing had he been dealt a different economic hand. Instead, he took office several months after the collapse of Lehman Brothers helped trigger a major financial crisis. At the time, China held nearly $1 trillion of the United States' debt, and the country's relatively strong economic growth represented a bright spot for American investors and corporations. For these reasons, the United States prioritized its economy over challenging Beijing.[102]

As part of the response to the 2008 economic recession, U.S. policymakers focused on supporting the troubled automotive industry. Bush and Obama both understood that the collapse of Chrysler would devastate Detroit and the communities across the country that depended on the automotive manufacturing sector. The Michigan-based

93 Marcus Noland, "US-China Economic Relations," Peterson Institute for International Economics, January 1996.
94 See, e.g., Jay Nordlinger, "Star-in-Waiting," National Review, November 17, 2004.
95 See, e.g., Transcript of President Clinton's March 2000 speech, "Clinton's Words on China: Trade Is the Smart Thing," The New York Times, March 9, 2000.
96 The White House, "President Grants Permanent Trade Status to China," Press Release, December 27, 2011.
97 See, e.g., Nathan Thornburgh, "The Invasion of the Chinese Cyberspies," Time Magazine, September 5, 2005
98 Human Rights Watch, "World Report China and Tibet, Events of 2005", Webpage, 2006.
99 Robert B. Zoellick, "Whither China: From Membership to Responsibility?," U.S. Department of State, September 21, 2005.
100 See, e.g., Jasmine Garsd, "The History of Tech Giant Huawei And The Chinese Government," NPR, December 7, 2018.
101 See, e.g., Steven Weisman, "Sale of 3Com to Huawei is derailed by U.S. security concerns," The New York Times, February 21, 2008.
102 See, e.g., Keith Bradsher, "China Losing Taste for Debt From U.S.," The New York Times, January 7, 2009; and Martin Wolf, "How Barack Obama rescued the US economy," Financial Times, January 10, 2017.

Center for Automotive Research (CAR) estimated that without federal intervention, approximately 2.6 million jobs would have been lost across manufacturing and non-manufacturing sectors, impacting suppliers and other dependent industries.[103]

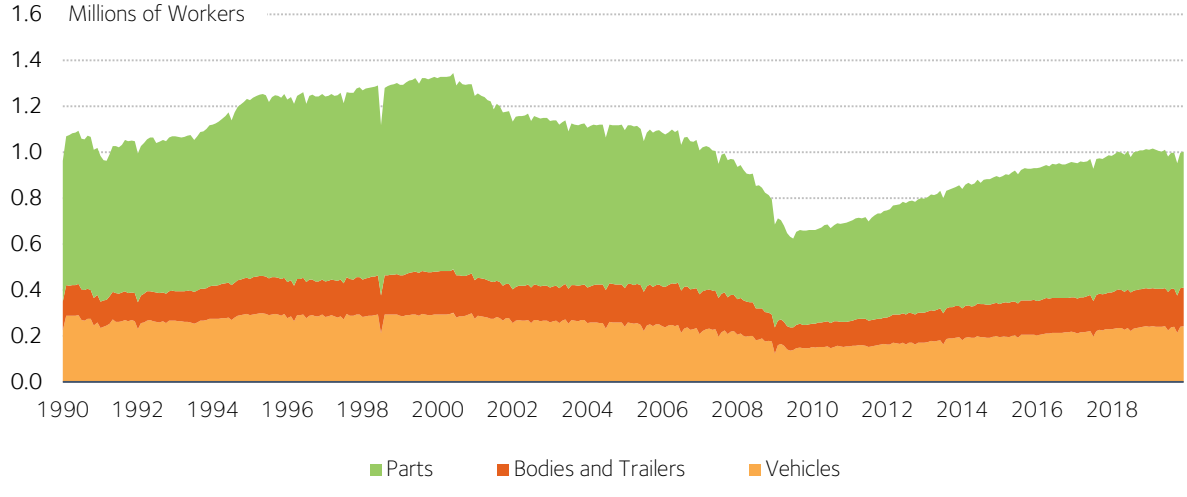
Sensing the potential economic damage inaction would create, U.S. policymakers bailed out the automakers, despite concerns from the general public. The $80 billion rescue of the automakers, which was eventually repaid, likely staved off the worst effects of a collapse and afforded the U.S. auto industry near-term relief and stability at a time when uncertainty rattled other key sectors of the economy. The bailout also allowed GM to continue developing its plug-in hybrid electric vehicle, the Volt, which launched in 2010 with a 35-mile all-electric range.[104]

Following the 2008 recession, the Obama Administration passed the American Recovery and Reinvestment Act of 2009 (ARRA), a massive stimulus bill, which renewed emphasis on modernizing the U.S. energy and transportation sectors.[105] After the 2008 financial crisis, there was widespread disagreement over whether the federal government should pursue an industrial policy. Some Republican senators argued that taxpayer money should not be used to prop up the auto industry, which they described as beyond salvage. Nevertheless, the Obama Administration pushed forward with a stimulus package that supported specific sectors, including the auto industry. GM alone received a $50 billion bailout.[106]

ARRA had four important impacts of relevance to the U.S. auto industry. First, it helped build a domestic manufacturing base for both electric vehicles and EV batteries. Second, it helped tap into growing public interest in sustainability and environmental concerns—for example, it provided consumers with $7,500 tax credit for buying an electric car. Third, it elevated the issue of energy security at the national level. Before the passage of ARRA, the United States had only two domestic firms dedicated to producing batteries, accounting for roughly two percent of global supply.[107] At the time, there was little concern about the United States' competition with China in the battery space because American allies, South Korea and Japan, dominated battery production.[108]

FIGURE 6

U.S. Auto Manufacturing Direct Employment



Source: BLS

103 Sean McAlinden and Debra Menk, "The Effect on the U.S. Economy of the Successful Restructuring of General Motors," Center for Automotive Research, December 5, 2013, at page 9.

104 See, e.g., General Motors, "Chevrolet Volt Adds Four States to Launch," Press Release, July 1, 2010.

105 U.S. Department of Energy, "American Recovery and Reinvestment Act of 2009," Alternative Fuels Data Center, Webpage.

106 See, e.g., Associated Press, "Top Republicans Oppose Auto Industry Bailout," The Wall Street Journal, November 16, 2008.

107 Jennifer Todd and Frankie Clogston, *Creating the Clean Energy Economy: Analysis of the Electric Vehicle Industry*, International Economic Development Council, 2013, at page 38.

108 Michael Grabell, "How the Stimulus Revived the Electric Car," ProPublica, January 31, 2012.

Finally, ARRA helped emphasize the proposition that American automakers should build products that would create jobs in the United States, rather than outsource them.

In 2008, the U.S. auto manufacturing industry employed 880,000 people: about 680,000 of them worked in auto parts manufacturing.[109] Nevertheless, the industry lost 435,000 jobs from 2000 to 2008.[110] In part to help reverse the decline and reinvigorate auto manufacturing jobs, the Obama Administration committed $2.4 billion across 48 advanced battery projects in cities across the country.[111] ProPublica found that the battery grants created and saved roughly 1,800 jobs, in areas like assembly lines, engineering, and toolmaking.[112]

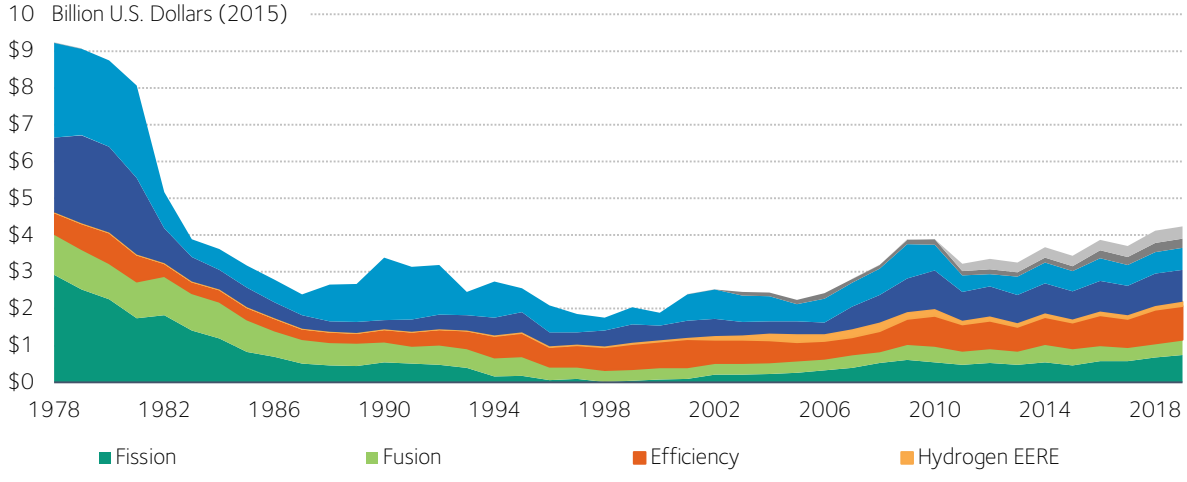
Ultimately, a portion of the $787 billion infusion into the economy from ARRA placed renewed emphasis on advanced fuel vehicles, which helped America secure an early lead on technologies such as EVs. Both U.S. government and industry-led projects opened new opportunities for assembly workers, toolmakers and engineers for an emerging technology.[113] Unfortunately, the response failed to help address longer-lasting structural issues in the U.S. automotive sector—declining sales, shrinking market share, and sustained job losses—that preceded the automotive industry's near-collapse.[114]

Government R&D & China's Investment in America

Even as the Obama Administration encouraged the development of EV technologies, the overall support for government R&D remained in steady decline: federal spending on R&D as a share of GDP dropped from 1.2 percent in 1976 to 0.6 percent in 2018.[115] The U.S. Department of Energy's

FIGURE 7

U.S. Department of Energy Spending on Energy R&D, 1978 – 2019



Note: Figure excludes one-time funding from the American Recovery and Reinvestment Act of 2009.
Source: Laura Diaz Anadon and Kelly Sims Gallagher, "DOE Budget Authority for Energy Research, Development, and Demonstration Database," Fletcher School of Law and Diplomacy, Tufts University; Department of Land Economy, University of Cambridge; and Belfer Center for Science and International Affairs, Harvard Kennedy School. August 27, 2019.

109 Bill Cannis and Brent D. Yacobucci, *The U.S. Motor Vehicle Industry: Confronting a New Dynamic in the Global Economy*, Congressional Research Service, March 26, 2010, at page 10.

110 Michaela Platzer and Glennon Harrison, *The U.S. Automotive Industry: National and State Trends in Manufacturing Employment*, Congressional Research Service, 2009, at page 8.

111 U.S. Department of Energy, "President Obama Announces $2.4 Billion in Grants to Accelerate the Manufacturing and Deployment of the Next Generation of U.S. Batteries and Electric Vehicles," August 5, 2009.

112 Michael Grabell, "How the Stimulus Revived the Electric Car," ProPublica, January 31, 2012.

113 Council of Economic Advisers, "A Retrospective Assessment of Clean Energy Investments in the Recovery Act," Executive Office of the President of the United States, February 2016, at page 7 and 44.

114 Note: The combined market share of the "Big Three"—GM, Ford, Chrysler—fell from 71 percent to 47 percent in the period between 1997 and 2008.

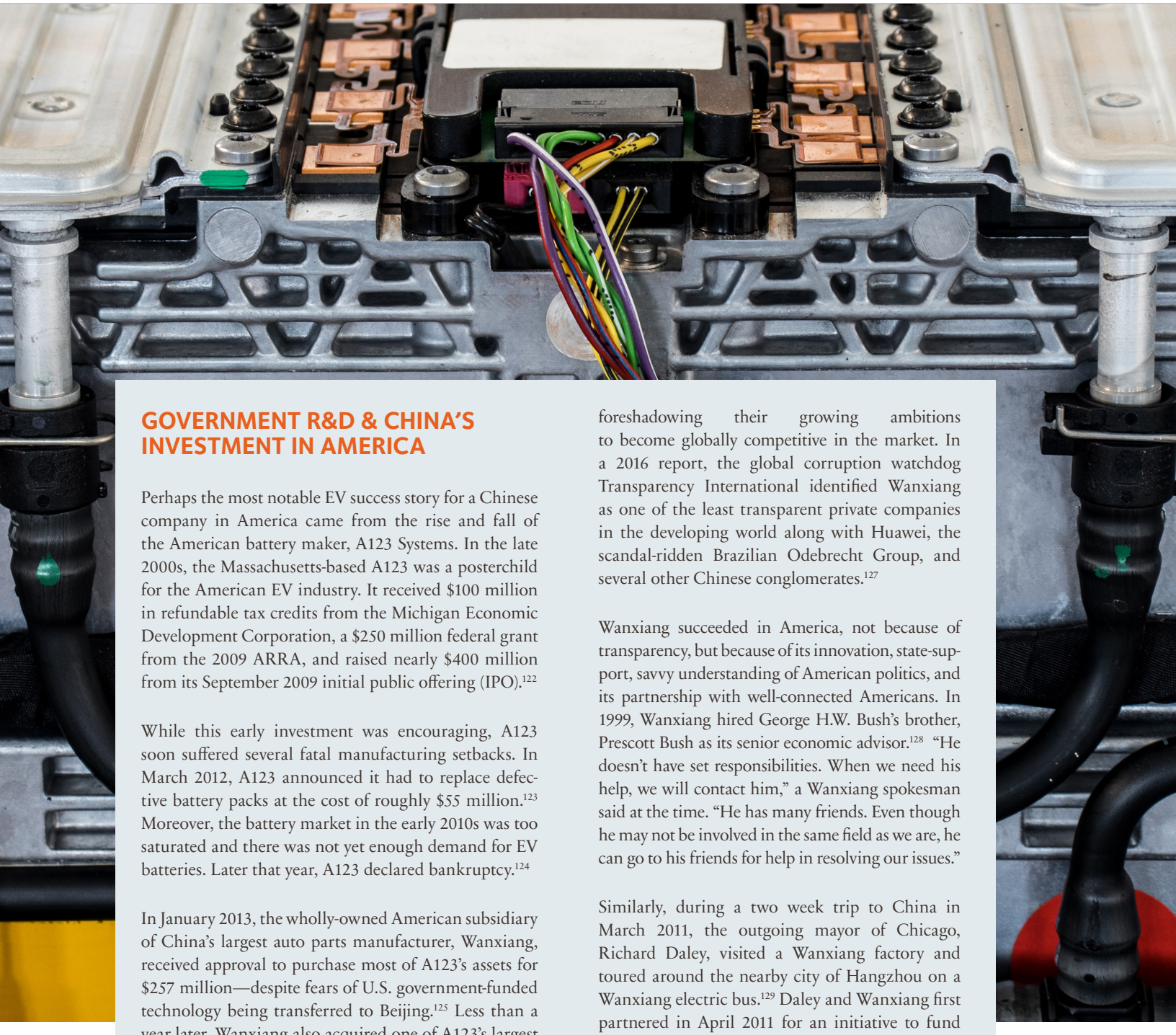
115 See, e.g., Matt Hourihan, "The FY 2020 Federal R&D Budget," American Association for the Advancement of Science, April 9, 2019; and The White House, "Federal Research and Development," 2019 White House Budget, Webpage.

Advanced Research Project Agency-Energy (ARPA-E) has, for example, received nearly $3.0 billion in appropriations since 2009 to fund batteries, automotive controls, and efficient EV chargers.[116] Yet, targeted initiatives—even in critically important areas such as battery technology—are simply not enough to compensate for a wholesale decline in federal research support, or the absence of a sustained strategy for how to best marshal federally funded research projects to support long-term national energy security goals.

In the 1960s, an estimated 70 percent of total R&D was federally funded, with the private sector filling in the rest. Today, the reverse is true.[117] Privately funded research supported by public funding is not only an important part of the U.S. economy but is also a crucial source of talent and capital, which helps keep U.S. industries competitive in markets around the world. The Defense Department's Advanced Research Projects Agency (DARPA), for example, birthed the Internet and the satellite navigation systems commonly used in smartphones.[118]

From 2010 to 2017, China more than doubled its spending on R&D to $445 billion, while its global share of patent applications—an imperfect but illustrative measure of innovation—grew to more than 40 percent, well above the United States' 16 percent.[119] During this time, the U.S. business community realized that China was not only a thriving market, but also a center of innovation and competition. Chinese companies also began to heavily invest in America. In 2016, China's investments peaked at $46 billion.[120] By the end of 2019, amidst the U.S.-China trade war, China's investments in all industries had fallen to $4.78 billion.[121]

116 See, e.g., Jieyi Lu, "Comparing U.S. and Chinese Electric Vehicle Policies," Environmental and Energy Study Institute, February 28, 2018.
117 See, e.g., Walter Isaacson, "How America Risks Losing Its Innovation Edge," Time, January 3, 2019.
118 See, e.g., Interview with Regina Dugan and Walt Mossberg, "Defense on the Offense," The Wall Street Journal, June 6, 2011.
119 Center for Strategic and International Studies, "Is China leading in global Innovation?," China Power, May 28, 2019.
120 See, e.g., Humza Jilani and Amy Cheng, "Chinese Investment in the U.S. Tanks Amid Major Policy Crackdowns," Foreign Policy, July 6, 2018.
121 See, e.g., The US-China Investment Hub.



GOVERNMENT R&D & CHINA'S INVESTMENT IN AMERICA

Perhaps the most notable EV success story for a Chinese company in America came from the rise and fall of the American battery maker, A123 Systems. In the late 2000s, the Massachusetts-based A123 was a posterchild for the American EV industry. It received $100 million in refundable tax credits from the Michigan Economic Development Corporation, a $250 million federal grant from the 2009 ARRA, and raised nearly $400 million from its September 2009 initial public offering (IPO).[122]

While this early investment was encouraging, A123 soon suffered several fatal manufacturing setbacks. In March 2012, A123 announced it had to replace defective battery packs at the cost of roughly $55 million.[123] Moreover, the battery market in the early 2010s was too saturated and there was not yet enough demand for EV batteries. Later that year, A123 declared bankruptcy.[124]

In January 2013, the wholly-owned American subsidiary of China's largest auto parts manufacturer, Wanxiang, received approval to purchase most of A123's assets for $257 million—despite fears of U.S. government-funded technology being transferred to Beijing.[125] Less than a year later, Wanxiang also acquired one of A123's largest customers in America, Fisker Automotive, for $149 million.[126] China had now acquired two American companies in the emerging EV space, perhaps foreshadowing their growing ambitions to become globally competitive in the market. In a 2016 report, the global corruption watchdog Transparency International identified Wanxiang as one of the least transparent private companies in the developing world along with Huawei, the scandal-ridden Brazilian Odebrecht Group, and several other Chinese conglomerates.[127]

Wanxiang succeeded in America, not because of transparency, but because of its innovation, state-support, savvy understanding of American politics, and its partnership with well-connected Americans. In 1999, Wanxiang hired George H.W. Bush's brother, Prescott Bush as its senior economic advisor.[128] "He doesn't have set responsibilities. When we need his help, we will contact him," a Wanxiang spokesman said at the time. "He has many friends. Even though he may not be involved in the same field as we are, he can go to his friends for help in resolving our issues."

Similarly, during a two week trip to China in March 2011, the outgoing mayor of Chicago, Richard Daley, visited a Wanxiang factory and toured around the nearby city of Hangzhou on a Wanxiang electric bus.[129] Daley and Wanxiang first partnered in April 2011 for an initiative to fund Americans studying Chinese. Soon after leaving office, Daley became a Wanxiang consultant.[130]

122 Jack McHugh, "Michigan Taxpayers Writing Check to Second Electric Car Battery Maker for $100 Million," Mackinac Center for Public Policy, July 15, 2010; Global Trade Alert, "United States of America: $249.1 million grant to A123 Systems for the manufacture of nano-iron phosphate cathode powder and electrode coatings," January 1, 2010; and Katie Fehrenbacher, "A123Systems Was Officially the Largest IPO of 2009," GigaOm, January 3, 2010.

123 See, e.g., Craig Trudell and Alan Ohnsman, "A123 Replacing Batteries That Led to Fisker Karma Shutdown," Bloomberg, March 26, 2011.

124 Brad Plummer, "A123 Systems files for bankruptcy: Here's what you need to know," The Washington Post, October 16, 2012.

125 See, e.g., Tom Hals and Ben Klayman, "Chinese firm wins A123 despite U.S. tech transfer fears," Reuters, January 29, 2013.

126 See, e.g., Peg Brickley, "Wanxiang Approved to Take Over Hybrid Maker Fisker Auto," The Wall Street Journal, February 18, 2014.

127 See, e.g., Kalyeena Makortoff, "China slammed as EM firms accused of 'pathetic' transparency levels," CNBC, July 11, 2016.

128 Susan V. Lawrence and Murray Hiebert, "The Bush family in China," Far Eastern Economic Review, October 12, 2000, at page 30.

129 Wanxiang America Corporation, "Chicago Mayor Visits Wanxiang on China Trip," Press Release, March 25, 2011.

130 See, e.g., Erin Ailworth, "A123 buyer quietly built presence," The Boston Globe, December 13, 2012.

Trump Administration Reimagines Competition with China

Before taking office, President Trump signaled that he would revolutionize America's relationship with China. In December 2016, Trump upended decades of protocol and tradition by accepting a congratulatory phone call from the Taiwanese President, Tsai Ing-wen.[131] The Trump administration's approach resonated with the American public and businesses, who were increasingly worried about China's rise and unfair trade practices. In 2018, Trump launched a trade war with China, and placed tariffs on tens of billions of Chinese imports. In addition to changing the economic relationship with China, the Trump administration also oversaw a shift in priorities for automated, connected, and electric vehicle (ACE) technologies.

The Obama administration had previously framed EVs as the answer to creating a clean and efficient transportation future, rather than continuing to rely solely on traditional fossil fuels. The administration believed federal dollars and research could create new markets and promote investment in, and the adoption of, more sustainable technology solutions.[132] The Obama administration also saw value in supporting other early-stage transportation technologies, such as AVs, to increase safety and reduce the human toll of more than 30,000 deaths on U.S. roads every year.[133] Finally, in 2016, the Obama administration announced a $400 million investment for research into 5G and next-generation mobile networks, which could support future connected vehicles.[134]

The Trump administration's approach has departed from the previous administration's approach in a few important respects. First, it views China with increased suspicion, rather than as a potential partner in addressing environmental and economic challenges. Second, it prioritizes energy dominance, which is a strategy that utilizes America's natural resources and expands export opportunities for domestic producers.[135] Energy security impelled greater government investment in EV research in the 1970s and 1980s, whereas today, there is growing concern that China may outperform the United States in developing and fielding cutting-edge technologies. However, recent actions have undercut the market development of these new technologies, for example, by weakening fuel economy standards and declining to expand programs like the electric vehicle tax credit.[136]

Reflecting the growing worry about Beijing's capabilities, the Trump administration's AV policies place a greater emphasis on cybersecurity. In January, the Trump administration released its third iteration of AV guidelines, which emphasized cybersecurity as a core issue.[137]

For 5G, the administration has framed its policy as seeking to win a race to develop the next-generation network and protect it from malicious actors. Earlier this year, the administration released its *National Strategy to Secure 5G*. The document articulated a comprehensive vision to promote both national security and economic leadership over 5G by: facilitating a domestic rollout of 5G, assessing and identifying the risks of 5G, managing those risks to American economic and national security, and promoting responsible development and deployment of 5G globally.[138] While official documents like the *National Strategy* rarely criticize China by name, the implication is clear: the White House sees China and its companies as the major threat in the 5G landscape.

Nowhere is this more important than in the debate around Huawei, the company arguably most poised to lead in the burgeoning 5G space. Huawei is building a telecommunications backbone that can link cities, roads, and cars, providing both additional road safety for drivers and raising worries about national security and surveillance. Having overtaken the Swedish firm Ericsson to become the world's largest telecommunications equipment maker in 2012, Huawei positions itself as an independent Chinese innovation story.[139] Many governments around the world worry about turning over their communications infrastructure to a firm that, at the very least, depends on the CCP for survival. Those governments share many of the same worries with Huawei's smaller, but equally opaque, Chinese rival, ZTE. These tensions increased after Canadian authorities, at the request of the United States, detained Huawei's chief financial officer, Meng Wanzhou, for allegedly violating U.S. sanctions against Iran.[140]

131 Anne Gearan, Philip Rucker, and Simon Denyer, "Trump's Taiwan phone call was long planned, say people who were involved," The Washington Post, December 4, 2016.
132 National Economic Council and Office of Science and Technology Policy, "A Strategy for American Innovation," Press Release, October 2015.
133 Insurance Institute for Highway Safety, "Fatality Facts 2018."
134 The White House, "Fact Sheet: Administration Announces an Advanced Wireless Research Initiative, Building on President's Legacy of Forward-Leaning Broadband Policy," Press Release, July 15, 2016.
135 The White House, "President Donald J. Trump Is Unleashing American Energy Dominance," Fact Sheet, May 14, 2019.
136 See, e.g., David Shepardson, "Trump budget proposes ending electric vehicle tax credit," Reuters, March 11, 2019.
137 See, e.g., Maggie Miller, "Cyber rules for self-driving cars stall in Congress," The Hill, September 26, 2019.
138 The White House, *National Strategy to Secure 5G*, March 2020.
139 See, e.g., Stu Woo, "Ericsson, Humbled by Huawei, Takes Another $1.8 Billion in Charges," The Wall Street Journal, January 16, 2018.
140 See, e.g., Dan Bilefsky, "Extradition Hearings Begin for Meng Wanzhou, Huawei Officer Held in Canada," The New York Times, January 20, 2020.

The biggest threat the United States faces with the proliferation of Huawei's 5G technology is that China could potentially control critical telecommunications infrastructure in both peacetime and in crisis.[141]

An American city that uses Huawei's 5G technology could find its traffic lights, cameras, and autonomous vehicles vulnerable to surveillance, direction, or destruction by Beijing's security forces. Today, the United States leads on developing AVs, but the 5G space is far more open to Chinese dominance.

141 Kadri Kaska, Henrik Beckvard, and Tomáš Minárik, *Huawei, 5G and China as a Security Threat*, NATO Cooperative Cyber Defence Centre of Excellence, 2019, at page 5.

China's Path to EV Dominance

The major automakers agree that the future transportation sector will be both electrified and digitized. Countries are now competing for EV leadership and are supporting the technology for its energy security or environmental benefits. Perhaps no other country has taken more decisive action on EVs than China.

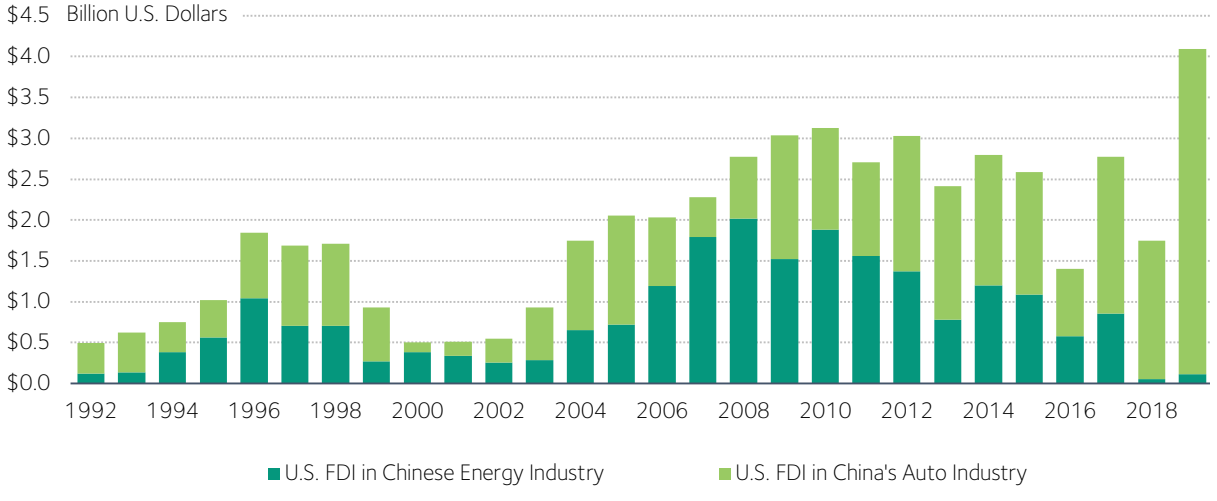
More than a decade of concerted government effort has culminated in the extraordinary growth of China's EV industry, which in 2018 sold more than one million EVs—three times the number sold in the United States.[142]

Beijing has long sought to develop a modernized transportation and automotive industry. However, China only became a prominent global EV competitor within the last five years, and it was not even an automotive powerhouse until the late 2000s. Prior to that, even if China had possessed the technological capacity to manufacture vehicles, it lacked a domestic market to support the industry. In 1984, for example, China already had a population of more than one billion but had only 5,600 privately-owned vehicles.[143] Rather than building an automotive industry from the ground up, Beijing instead encouraged foreign companies to manufacture cars in China, while also developing a domestic auto parts industry. Both actions would help China close the gap between its manufacturing capabilities and those of other global leaders, such as the United States.

China had a lot to offer global car manufacturers in the 1980s

FIGURE 8

United States' Foreign Direct Investment in China, Select Industries



Source: The U.S.-China Investment Hub

142 SAFE analysis based on data from Bloomberg.

143 Joe Studwell, *The China Dream: The Quest for the Last Great Untapped Market on Earth*, 2002, at page 24, 83.

and 1990s, including sizable tax breaks, extremely cheap labor, and the promise of access to an untapped and growing market. This enticed many of the world's largest automotive companies, and they began investing heavily in China.

In February 1994, a Chinese state planning body announced that it would license, at most, three foreign car factories in the years leading up to 2000.[144] In its attempt to win a coveted license, GM agreed to commit $350 million to 15 Chinese factories, $40 million for a center on automotive design, as well as funding university studies on vehicle production.[145] GM believed that to succeed in China, it needed to help China learn how to design and build a car.[146] China's GDP per capita at that time was under $500, and it was inconceivable to American companies that Chinese companies would seriously threaten their business.[147]

The Flight of Technology and Foreign Partnerships

China's attraction of foreign automakers led to a golden age of technology transfer, through joint ventures, collaboration, and sometimes, outright theft. For example, GM executives pushing for partnership with Beijing in the 1990s did not anticipate that the state-owned enterprise, Chery, would develop a car that was almost identical to the Chevy Spark—and retail for $1,500 less.[148] The cars were so similar that one could remove a door from one and securely fit it onto the other.[149] Even the name Chery, established in 1997, decades after Chevy, was just one letter away from the original car brand.

Discouraging lawsuits against Chinese companies was an unstated but important part of Beijing's strategy. While Chinese officials rarely discussed lawsuits explicitly, most American firms were dissuaded from suing because they feared it would offend Beijing and jeopardize their access to China's market.

Those who did follow through with lawsuits often served as cautionary tales to others. The courts were clearly biased toward Chinese companies, and American automakers soon learned that the lawsuits were rarely worth the trouble. In the early 2000s, for example, six international automakers, including Audi and BMW, banded together against a Chinese glass factory for making counterfeit windshields.[150] Local prosecutors downplayed the case, and blamed a Taiwanese businessman who had left the country, even though a local entrepreneur in fact ran the factory. In late 2004, the automakers finally won the case, but lost the war: the court ordered the glass factory's chairman to pay a personal fine of just $12,000.[151]

While GM sued Chery in 2004 for copying the Chevy Spark's vehicle design, the parties settled confidentially, with GM reportedly receiving little, or even nothing, in compensation.[152] Despite this early controversy, by 2005 GM had become the top-selling foreign automaker in China.

In addition to developing partnerships with foreign auto manufacturers, China prioritized the development of its own auto parts industry, which it could use to strengthen relationships with Western and Japanese auto manufacturers, and gain a foothold in developed markets.[153] China's auto parts market grew rapidly, largely due to an estimated $27 billion in direct and indirect subsidies to the industry from 2001 to 2011.[154] By 2010, China had captured more than 40 percent of the global auto parts market.[155] Growth continued as foreign companies invested nearly $11 billion in China's auto parts industry from 2013 to March 2019.[156] Wanxiang, the same company that began purchasing U.S. EV assets in 2013-2014, is one of China's largest auto parts manufacturers today.[157]

Foreign automakers benefitted from the efficient and low-cost auto parts supply chain, which allowed them to offer more competitive prices for their cars. The supply chain also made China an attractive place to do business. It benefited Chinese start-ups as well, which saw an opportunity to meet growing domestic demand—as Chinese consumers had started to accumulate sufficient wealth to afford personal automobiles. By the mid-2000s, China had more than 120 companies making passenger cars.[158] In 2010, the private

144 Ibid. at page 128.
145 Ibid.
146 Ibid. at page 128 – 130.
147 World Bank, "GDP per capita (current US$) – China," Webpage, 2020.
148 See, e.g., Forbes, "Stolen Cars," February 16, 2004.
149 See, e.g., Jamie Butters, "How GM adjusts to China is crucial to its future," Knight Ridder Tribune News Service, January 17, 2005.
150 See, e.g., David Ibison, "Honda sues Chinese carmaker over copying," Financial Times, December 9, 2004.
151 Ibid.
152 Ibid.; and See, e.g., James Mackintosh and Geoff Dyer, "GM and Chery settle legal action," Financial Times, November 18, 2005.
153 See, e.g., Colum Murphy and Jeff Bennett, "China's Strategy in U.S. Car Market: Make Parts First," The Wall Street Journal, September 18, 2015.
154 Usha Haley, "Putting the Pedal to the Metal," Economic Policy Institute, January 31, 2012, at page 20.
155 Deloitte, *Gaining Momentum: Recent Trends in China's automobile parts market*, 2011, at page 1.
156 David Coffin, China's Growing Role in U.S. Automotive Supply Chains, Office of Industries of the U.S. International Trade Commission (USITC), August 2019, at pages 3 and 5.
157 Ibid.
158 Ted Fishman, *China Inc.: The Relentless Rise of the Next Great Superpower*, December 11, 2012, at page 204.

company Zhejiang Geely acquired Volvo, the first time a Chinese automaker purchased a respected Western brand. Yet, despite many encouraging developments, most of those companies were unable to match the quality and reliability of foreign automakers' internal combustion engines.

China's Early EV Industry

As a latecomer to the automotive sector, in the early 21st century Beijing decided it would be advantageous to change course and focus on EV technology. Established carmakers had been refining internal combustion engine technology for decades, and although they had transferred some technology to Chinese companies, it was difficult for China to compete against companies that had far more experience building engines. Moreover, because EVs were a new technology that requires few moving parts, focusing on EVs removed many of the advantages held by American, German, and Japanese legacy manufacturers—none of which had yet developed a mass market EV. Most importantly, Chinese companies could benefit from broad government support—which would change the nature of the competition, as foreign companies had to compete with an increasingly powerful Beijing.

Beijing's first steps toward EVs, however, were tentative. China's Ministry of Science and Technology (MOST) first announced a policy referencing EVs in 2001, which outlined initial research activities into their technology and manufacturing methods.[159] While the vast majority of early Chinese funds for vehicular transport went to the development of internal combustion engine vehicles, by 2006, more than 3,000 advanced fuel vehicles were sold, providing the momentum Beijing needed to take more aggressive steps to support EV technology.[160]

In 2006, China began implementing policies to incentivize private companies to produce EVs.[161] China's MOST and the National Development and Reform Commission (NDRC) launched preliminary programs to fund electric vehicle research and development. The first of such programs, Project 863, was a precursor to *Made in China 2025*. Project 863 provided funding for more than a dozen high-tech industries, including $174 million for EVs, which represented the first substantial allocation of funds toward EV development.[162] In 2008, MOST and NDRC announced that they would put at least 1,000 hybrid, fuel-cell, and all-electric vehicles on the road in 10 different cities.[163]

The policies and subsides created by China's central government began to produce results. In 2008, for example, the Chinese company Build Your Dreams (BYD) became the first to mass-produce an EV for the Chinese market.[164] BYD had launched an automotive unit in 2003 after acquiring a small state-owned car manufacturer. It grew rapidly, buoyed by Berkshire Hathaway's purchase of nearly 10 percent of the company in September 2008.[165] By 2009, BYD had become the top-selling automaker in China without a joint venture (JV) partner.[166] That success was mirrored in BYD's development of electric buses, which it began mass-producing that year.[167] In 2013, BYD established an electric bus factory in Lancaster, California; that same year, BYD debuted the first fully electric buses for public use in London.[168]

While China celebrated BYD's accomplishments, BYD succeeded only after it had stolen technology from competitors.[169]

For example, U.S. suppliers complained that BYD would order parts like door panels—and then reverse engineer the components.[170] Its popular F3 model was a chimera of stolen car technology: it featured a Mitsubishi engine, a Buick HRV hatchback rear, and a Toyota Corolla front.[171] This theft worked to BYD's advantage: by 2009, the F3 was the top-selling car in China.[172]

159 Martin Lockstrom, Thomas Callarman, and Liu Lei, "The Electric Vehicle Industry in China and India: The Role of Governments for Industry Development," Industrial Dynamics in China and India, January 2011, at pages 66-67.
160 Peng Yu et al., "The Evolution of China's New Energy Vehicle Industry from the Prospective of Technology-Market-Policy Framework," Sustainability, 2019, at page 11.
161 Shiqi Ou et al., "A Study of China's Explosive Growth in the Plug-in Electric Vehicle Market," Oak Ridge National Laboratory, January 2017.
162 U.S. Chamber of Commerce, *Made in China 2025: Global Ambitions Built on Local Protections*, 2017; and IEA, *Hybrid and Electric Vehicles: The Electric Drive Captures the Imagination*, March 2012, at page 199.
163 See, e.g., William Pentland, "Why China May Save The Electric Car," Forbes, October 27, 2008.
164 BYD, "BYD, Toyota Agree to Establish Joint Company for Battery Electric Vehicle Research and Development," Press Release, November 7, 2019.
165 See, e.g., Bloomberg, "Buffett to Visit BYD in China Amid Declining Sales, Disputes," September 22, 2010.
166 Michael Wei, "Factbox: China becomes the world's No. 1 auto market," Reuters, January 8, 2010.
167 Paulson Institute, "California Dreaming: How a Chinese Battery Firm Began Making Electric Buses in America," Paulson Papers on Investment, June 2015.
168 See, e.g., Anthony York, "Chinese firm to open bus factory in Lancaster," Los Angeles Times, April 16, 2013; and Mark Magnier, "Bus, stopped," South China Morning Post, November 15, 2019; and Will Nichols, "Electric Buses Hit London Roads," The Guardian, December 19, 2013.
169 Usha C.V. Haley, "Putting the pedal to the metal Subsidies to China's auto-parts industry from 2001 to 2011," Economic Policy Institute, January 31, 2012, at page 30.
170 Ibid.
171 "China IPR: Carmaker BYD Seeks to "Build Your Dreams" Based on Someone Else's Design," October 30, 2009.
172 Akshat Rathi and Echo Huang, "Inside BYD- the world's largest electric vehicle maker," Quartz, December 13, 2018.

JOINT VENTURES A TOOL FOR CHINA TO GAIN LEVERAGE OVER AMERICAN COMPANIES

China's EV policies expanded while the United States was struggling with the 2008 financial crisis, affording Beijing an opportunity to extend its leverage over American carmakers like GM. The U.S. Treasury Department refused to permit GM to spend its bailout money on its foreign operations, so GM asked its Chinese joint venture partner, the state-run Shanghai Automotive Industry Corporation (SAIC), for help. SAIC helped GM secure a $400 million commercial bank loan. Shortly thereafter, GM agreed to help SAIC develop an electric vehicle.[173]

Beijing's approach to automotive JVs is often a three-step process. First, Beijing partners with a leading global automaker. Next, Beijing absorbs the secrets of those automakers' manufacturing, engineering, and car design. Finally, Beijing starts building and selling cars under a Chinese brand name. The JV between GM and SAIC closely followed this approach.[174]

In 2010, GM and SAIC, along with the Chinese automaker Wuling, began selling a jointly developed car. Over the course of the next several years, GM increased its sharing of technology with SAIC, and the two companies announced a plan for long-term collaboration on EV development. In 2012, SAIC began selling cars that incorporated GM technology under its own brand names.[175]

173 See, e.g., Edward Niedermeyer, "The secret history of GM's Chinese bailout," Quartz, January 24, 2016.

174 Ibid.

175 Ibid.

China had no official policy on EV batteries until 2008, when Chinese policymakers, via the Ministry of Industry and Information Technology (MIIT), began subsidizing the development of battery manufacturing, in much the same way they had been subsidizing EVs. Beijing knew that success in EV technology could pose a problem if China was forced to rely on other countries for batteries. Before 2000, South Korea and Japan had produced most of the world's batteries.[176] The desire to reduce reliance on the Japanese battery industry was part of the original impetus for China to integrate its EV battery supply chain, including the raw products, anodes and cathodes, and battery materials.[177] The countries fought two wars in the 20th century, with Japan occupying huge swaths of China during World War II. Chinese leaders feared becoming reliant on Japanese technologies and supply chains — arguably even more than they feared relying on the United States.

EV Policy Cohesion

China's EV policies have been carefully crafted to advance Beijing's domestic interests. For example, Beijing has long been concerned with the American naval presence near the Strait of Malacca, one of the world's most important oil transit chokepoints—through which China receives a majority of its imported oil.[178] By committing to adopt EVs that reduce its dependence on oil, Beijing would make itself less vulnerable if tensions between the United States and China were to increase. In addition, EVs create opportunities for Chinese companies to benefit from a growing EV industry, and gain global recognition and credibility by developing sophisticated technology at a low cost. EVs are also an attractive solution to China's current and future environmental challenges. In short, Beijing has spent an outsized amount of money on EV policy because it allows China to accomplish a multitude of the central government's goals simultaneously.

Following significant investments to develop its EV technology, China soon turned to policies that would stimulate demand. China began testing EV subsidies for consumers in five major cities as early as 2009.[179] Beijing also continued to refine policies to support EV component manufacturing and provided low interest loans to potential EV makers.[180]

Beijing did not launch its first EV charging station until May 2010, and by June 2013, China only had roughly 400 stations, compared with more than 20,000 in the United States.[181] Recognizing that it was far behind other leading countries, China implemented a wide array of subsidies, created new municipal plans, and made overtures to private investors to support an EV infrastructure build-out.[182]

Beijing divides its wide array of subsidies and other methods of support for the EV industry amongst various companies and institutions, as well as provincial and local governments. Beijing derived many of the major tenets of Chinese investment and subsidy programs from EV policies already implemented in the United States and Western Europe, but by late 2014, Chinese policymakers started demonstrating a strong understanding of the demands of Chinese consumers. For example, in order to purchase any passenger vehicle in China, consumers must first enter a lottery or auction system to obtain a license plate.[183] The process for obtaining a license plate can take several years, and the value of a license plate for a single vehicle can reach $19,000.[184] The central government has incentivized consumers to purchase EVs by offering an expedited registration process. Beijing also implemented other contemporaneous programs—such as restricting investment for internal combustion engines and mandating the purchase of credits for automakers that do not meet minimum production quotas for EVs.[185]

When Beijing first introduced EV subsidies for batteries, it established minimum safety standards.[186] Within two years of market testing, though, it became evident that the less expensive batteries preferred by Chinese automakers, which used Lithium Iron Phosphate (LFP) cathodes, were weaker and had more durability concerns relative to other battery chemistries available on the global market—even though they were seen as relatively safe.[187] Beijing then increased the energy density required for EV batteries to receive subsidies. This caused EV producers to pivot toward cobalt-derived batteries—because cobalt battery compositions were the only type of chemistries that could meet the new EV subsidy standards at that time.[188]

176 See, e.g., SCUD, "China's Rapid Growth in the Lithium-Ion Battery Industry," September 2011.
177 Donald Chung et. al., "Automotive Lithium-ion Battery (LIB) Supply Chain and U.S. Competitiveness Considerations," Clean Energy Manufacturing Analysis Center, June 2015.
178 Eleanor Albert, "Competition in the Indian Ocean," Council on Foreign Relations, May 19, 2016.
179 Christopher Marquis et. al.,"China's Quest to Adopt Electric Vehicles," Stanford Social Innovation Review, Spring 2013.
180 Ibid.
181 Shuo Huang, "China's First Electric Vehicle Charging Station Put into Service," People's Daily Online, April 1, 2010; and Sabrina Howell, Henry Lee, and Adam Heal, *Leapfrogging or Stalling Out? Electric Vehicles in China*, Harvard Kennedy School, July 15, 2014, at page 25; and Nick Marro, Hengrui Liu, and Yu Yan, "Opportunities and Challenges in China's Electric Vehicle Market," China Business Review, February 2, 2015.
182 Ibid.
183 Hui He, Lingzhi Jin, Hongyang Cui, and Huan Zhou, "Assessment of Electric Car Promotion Policies in Chinese Cities," The International Council on Clean Transportation (ICCT), October 2018.
184 Ibid.
185 Bradley Berman, "Beijing shifts from EV subsidies to setting quotas for automakers," Electrek, December 6, 2019.
186 China's National Development and Reform Commission, "Statement 551," September 17, 2013.
187 Kangda Chen et Al., "Selection of Lithium-ion Battery Technologies for Electric Vehicles under China's New Energy Vehicle Credit Regulation," Energy Procedia, February 2019, at page 3043.
188 Marcelo Azevedo et al.,"Lithium & cobalt: A Tale of Two Commodities," McKinsey & Company, June 2018.

Beijing's EV battery policy had two major effects. First, it culled the low performing battery makers and EV manufacturers.[189] In addition, as Chinese battery purchasers responded to incentives and rushed to purchase cobalt, the price of the mineral spiked, causing fear and alarm among global investors and buyers, and particularly non-Chinese EV manufacturers.[190]

Another important development in China's EV policy occurred in September 2016, when MIIT proposed a new regulatory program to force Chinese automakers to sell a minimum number of new energy vehicles (NEVs).[191] This program required automakers to obtain a certain number of advanced fuel vehicle credits annually. Surplus NEV credits could be transferred and traded to other automakers. The policy created a parallel, fluid system to regulate and control the manufacturing of both traditional autos and EVs. Similar to California's Zero Emission Vehicle (ZEV) program, China's NEV credit system set increasing requirements for automakers in 2019 and 2020.[192]

Although local governments in China scaled back subsidies in 2019, central and local authorities implemented and extended subsidies in early 2020, after the coronavirus devastated China's economy.[193] In the first quarter of 2020, EV production dropped more than 60 percent, while sales fell by more than 50 percent.[194] The subsidies included incentives for buyers, and $399 million for battery charging infrastructure. By December 2019, China reportedly had more than 530,000 public chargers, accounting for more than 65 percent of the global total.[195] Moreover, in April 2020, a top NDRC official announced a further $1.4 billion investment in the country's EV infrastructure, with the goal of growing the country's charging network in 2020 by 50 percent.[196] While Beijing's statistics are sometimes inaccurate, and the Chinese government sometimes fails to meet its policy goals, Beijing is prioritizing expanding its charging network, and increasing uptake of EVs, despite the challenges coronavirus has created.[197]

China's Coercion of Global Companies

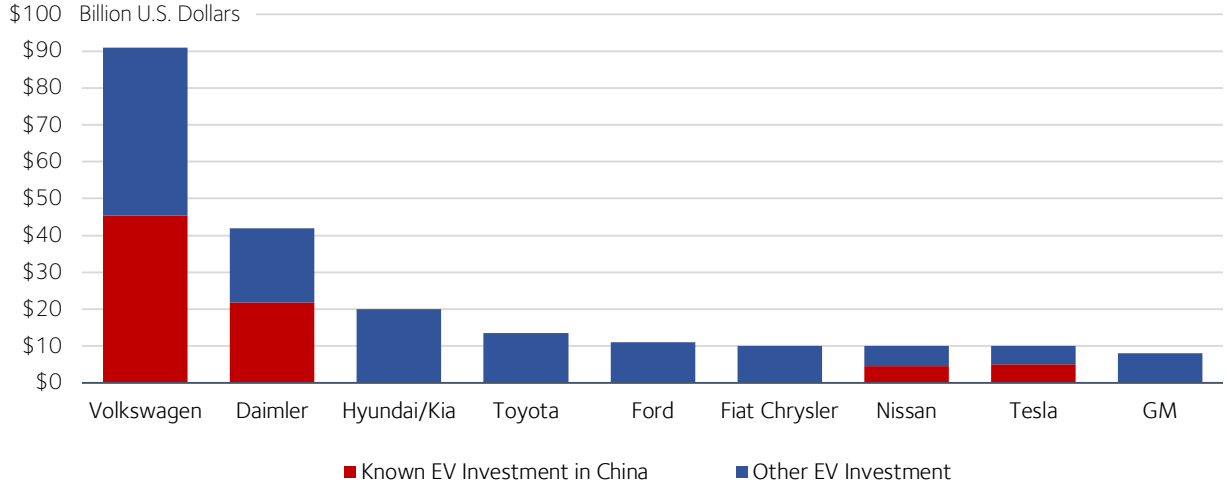
While public policy has been an important tool for governments around the world to support transportation electrification, Beijing's strategy toward applied research for EVs is unique. Much of the funding for China's EV industry has come not from Beijing, but from automakers and other global companies.[198] For example, global automakers anticipate spending $135 billion over the next ten years on Chinese EV projects alone.[199] While China has provided market access to these companies, Beijing has taken advantage of its market position by forcing or coercing companies to subsidize Chinese research or purchase Chinese technology.

Consider the Chinese EV battery company, Contemporary Amperex Technology Ltd. (CATL). Spun out of a small company that made batteries for laptops and MP3 players in 2011, CATL benefitted greatly from Chinese EV subsidies and programs. In 2015, Beijing issued an unofficial mandate that required automakers to purchase batteries from a Chinese supplier in order to qualify for government subsidies.[200] While Beijing technically permitted foreign companies to produce and sell EVs that used non-Chinese batteries, Chinese officials privately pressured foreign companies to only use Chinese battery suppliers.[201] Locally produced cars are "obligated to use local batteries," the chief executive of Volkswagen Group China said in January 2018.[202]

At the time, CATL was the only Chinese company with the ability to produce at scale, so Volkswagen, Daimler AG, Toyota, and Honda, all had no choice but to use CATL batteries if they wanted to maintain or increase their operations in China.[203]

189 Liu Junjing, "Cancellation of subsidy policy for cars with less than 150 km affects over 70% of new energy vehicle products," eeo.com.cn December 15, 2017, available at: http://www.eeo.com.cn/2017/1215/318918.shtml.
190 See, e.g., Eric Ng, "China goes all out to secure lithium, cobalt supplies – key to dominating the world electric car market," South China Morning Post, June 4, 2018.
191 International Council on Clean Transportation, "China's New Energy Vehicle Mandate Policy (Final Rule)," International Council on Clean Transportation, January 2018, at page 1.
192 Ibid.
193 Yi Huang et al., "Saving China from the coronavirus and economic meltdown: Experiences and lessons," VOX,, CEPR Policy Portal, March 23, 2020.
194 The Straits Times, "Europe beats China in Q1 electric vehicle sales, study shows," April 24, 2020; and Carrie Shi, "China's NEV output, sales in Q1 more than halved by Covid-19," Fastmarkets MB, April 15, 2020.
195 Note: The U.S.-China exchange rate used for this report is 6.77 RMB to the dollar. Evelyn Cheng, "Electric cars take the spotlight in China's post-coronavirus stimulus plans," CNBC, May 3, 2020; and IEA, *Global EV Outlook 2019*, May 2019, at page 40; and Zheng Xin, "Charging piles construction to accelerate across country," China Daily Global, June 2, 2020; and IEA, *Global EV Outlook 2020*, June 2020.
196 Jill Shen, "China Is Investing RMB 10 Billion in EV Charging Infrastructure," TechNode, April 10, 2020.
197 Ibid.
198 Paul Lienert, Norihiko Shirouzu, and Edward Taylor, "VW, China spearhead $300 billion global drive to electrify cars," Reuters, January 10, 2019.
199 Ibid.
200 Echo Huang, "China's breaking up the EV battery monopoly it carefully created," Quartz, June 25, 2019.
201 Ibid.
202 Jie Ma, David Stringer, Yan Zhang, and Sohee Kim, "The Breakneck Rise of China's Colossus of Electric-Car Batteries," Bloomberg, February 1, 2018.
203 Ibid.

FIGURE 9
Planned EV Investment Through 2029, Select Automakers



Source: Reuters analysis completed April 2019.

While this approach propelled CATL to become the world's largest EV battery manufacturer, CATL also received support through more traditional means.[204] In 2017, Germany convinced China to support CATL in building a $272 million plant in the German state of Thuringia—despite the high cost of taxes, labor, and energy in the region.[205] In exchange, Germany would share high-tech R&D with the company.[206]

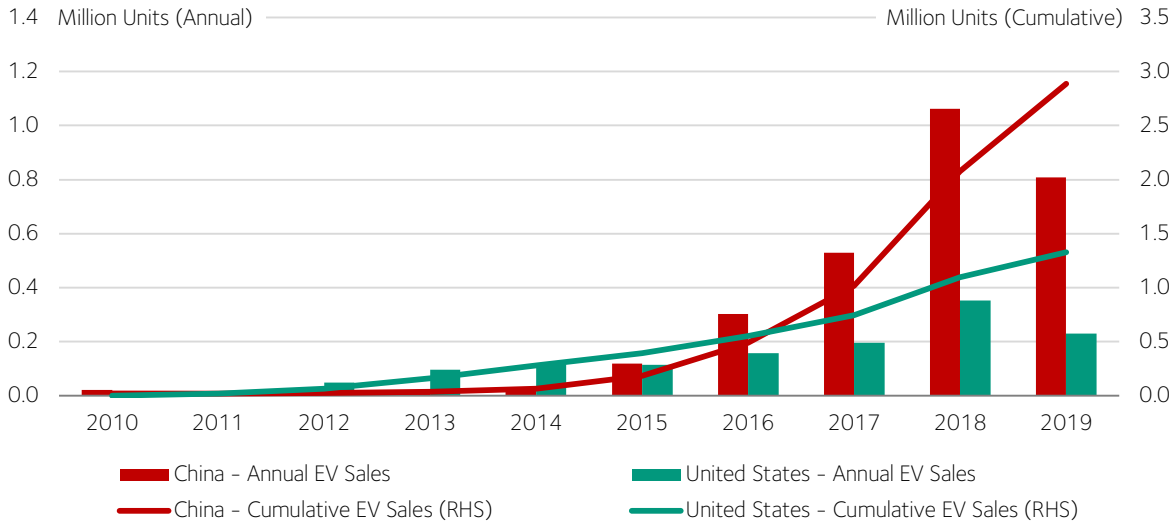
In 2019, Beijing dialed back some of its policies that favored Chinese companies in the EV sector, like the policy that required automakers to purchase from Chinese suppliers.[207] However, these policies have provided companies like CATL a major head start on its global competition. CATL's revenue increased nearly eightfold from 2015 to 2019, and the company currently supplies more than 40 percent of the batteries that go into Chinese EVs.[208] Now, even Tesla, which has a longstanding agreement with Japanese battery-maker Panasonic, has signed an agreement to use CATL's cobalt-free batteries for its China operations.[209]

China's Present EV Dominance

China surpassed the United States in annual EV sales in 2015, and is expected to maintain its leadership in the EV market with a 57 percent market share in 2030.[210] This lead is largely the result of Beijing's support for its EV industry, which has amounted to roughly $60 billion since 2009.[211] This investment has resulted in a rapid expansion of the industry, with at least 450 EV companies currently operating in China.[212] While many of China's EV companies are small, some are already global leaders. For example, China's BYD has grown to become the world's second largest EV company in terms of sales, behind only Tesla.[213] BYD's focus on affordable vehicles has spurred its growth: its Tang electric SUV, for example, retails for $35,700.[214] In April 2019, BYD launched a subcompact EV

204 See, e.g., Heekyong Yang and Hyunjoo Jin, "The world's biggest electric vehicle battery makers," Reuters, November 26, 2019.
205 Birgit Jennen and Brian Parkin, "China Is Bypassing Governments to Gain Influence in Europe," Bloomberg, January 14, 2019.
206 Ibid.
207 See e.g., Deng Ya, "Electric vehicle battery whitelist 'dies,' but effects will not be massive," D1EV, June 26, 2019, available at: https://www.d1ev.com/news/zhengce/93579.
208 Heekyong Yang and Hyunjoo Jin, "The world's biggest electric vehicle battery makers," Reuters, November 26, 2019; and Shirley, "CATL reports YoY net profit growth of 31.4% in 2017," China Automotive News, March 13, 2018; and Monika, "CATL's 2018 annual report shows 48.08% jump in revenue while net profit drops 12.66%," China Automotive News, April 25, 2019; and Xinhua, "China battery giant CATL posts 29 pct profit growth in 2019," February 27, 2020; and See, e.g., Tefor Moss, "The Key to Electric Cars Is Batteries. One Chinese Firm Dominates the Industry," The Wall Street Journal, November 3, 2019.
209 Zhang Yan, Yilei Sun, and Brenda Goh, "Tesla in talks to use CATL's cobalt-free batteries in China," Reuters, February 18, 2020.
210 IEA, *Electric Vehicle Outlook 2019*, May 2019.
211 Scott Kennedy and Mingda Qui, "China's Expensive Gamble on New-Energy Vehicles," Center for Strategic and International Studies, November 6, 2018.
212 Scott Kennedy and Daniel Rosen, "Market Metrics: A Fact-Based Approach to the Chinese Economic Challenge," Center for Strategic and International Studies, October 10, 2019; and Akshat Rathi, "Five things to know about China's electric-car boom," Quartz, January 8, 2019
213 Felipe Munoz, "Global sales of pure electric vehicles soar by 92% in H1 2019," JATO, July 29, 2019.
214 See, e.g., Matthew Campbell and Ying Tian, "The World's Biggest Electric Vehicle Company Looks Nothing Like Tesla," Bloomberg, April 16, 2019.

FIGURE 10
U.S. and China Electric Vehicle Sales, 2010 – 2019



Note: SAFE analysis based on data from Bloomberg.

which retailed for $8,950, after accounting for government subsidies.[215]

In addition to succeeding with domestic passenger EVs, China also dominates the electric bus, taxi, and commercial vehicle markets. By late 2018, approximately 425,000 electric buses had been deployed globally—with roughly 421,000 of those located in China.[216] Bloomberg New Energy Finance projects China's electric bus fleet to surpass 600,000 by 2025, with the United States deploying less than 5,000.[217] Deploying these buses has been expensive; until 2016, China's top bus manufacturers could receive a $150,000 subsidy for certain electric buses.[218]

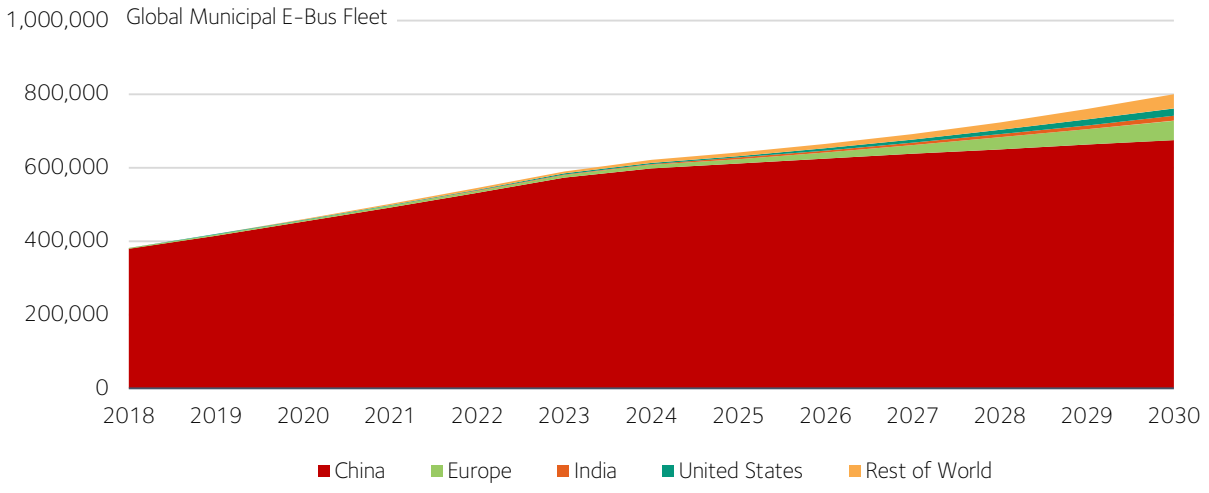
China's commanding lead in the electric bus market has allowed it to expand beyond China and provide buses for transit agencies around the world, including the United States. Companies such as BYD have been able to gain a foothold in these markets because they not only receive subsidies from China, but can also exploit subsidies provided by other countries.[219] In recognition of the unfair competitive advantage this provides China, U.S. policymakers included a provision in the National Defense Authorization Act (NDAA) to block Chinese bus companies from manufacturing in the United States.[220]

China has also spent prolifically to electrify its taxi fleet. Currently, there are at least 20,000 EV taxis in the southern Chinese metropolis of Shenzhen, while many major U.S. cities have few, if any, EV taxis.[221] This is a model China hopes to replicate in many of its major cities, like Beijing, where the state-run firm Beijing Automotive Industry Holding Co. (BAIC) announced a plan to deploy 20,000 new EV taxis by 2020, for an all-electric fleet.[222]

Commercial vehicle operators such as delivery and logistics companies have also signaled growing interest in medium-duty vehicles powered by electricity. Battery prices have fallen precipitously in the last several years and new entrants have produced a number of models that could soon make medium-duty electric vehicles (MDEVs) economically advantageous for specific use cases and duty cycles.[223] As the proliferation of e-commerce continues to increase demand for their services, these companies are

215 Ibid.
216 Brian Eckhouse, "The U.S. Has a Fleet of 300 Electric Buses. China Has 421,000," Bloomberg, May 15, 2019.
217 Ibid.
218 See, e.g., Gerry Shih, "With State Subsidies and a Firm Hand, China Races Ahead with Electric Transport," The Washington Post, June 2, 2019; and Xiangyi Li et al., "How to Enable Electric Bus Adoption in Cities Worldwide," World Resources Institute, 2019, at page 17.
219 See, e.g., Jessica Wehrman, "NDAA provision targets Chinese rail cars and electric buses," Roll Call, December 10, 2019.
220 Ibid.
221 See, e.g., Rita Liao, "First buses, now Shenzhen has turned its taxis electric in green push," Tech Crunch, January 4, 2019.
222 Jill Shen, "Beijing will replace all taxis with electric cars in two years," TechNode, July 3rd, 2019.
223 Pippa Stevens, "The battery decade: How energy storage could revolutionize industries in the next 10 years," CNBC, December 30, 2019.

FIGURE 11
Electric Bus Forecast, 2018 – 2030



Note: Bloomberg New Energy Finance

beginning to seriously evaluate the potential for integrating MDEVs into their fleets. For example, Amazon plans to deploy 100,000 electric delivery vans by 2024.[224] Despite great interest from industry, these vehicles are not yet being produced in the United States at the scale or pace necessary to meet companies' needs.

However, China is already producing these vehicles. By 2019, it had nearly 250,000 electric light commercial vehicles on the road, accounting for roughly 65 percent of the global total.[225] This has forced American companies to turn to China. In November 2019, for example, FedEx announced the purchase of 1,000 electric trucks from Chanje, a brand owned by the Chinese EV firm Five Dragons Group.[226]

Besides Beijing's commitment to subsidizing and supporting the EV industry, China has also built robust supply chains for its EVs, particularly by ensuring it has sufficient supply of the minerals required to produce EV batteries and components, underscoring the tactics and strategy Beijing has used to become the world's largest EV market.

224 See, e.g., Elijah Shama, "Amazon is purchasing 100,000 Rivian electric vans, the largest order of EV delivery vehicles ever," CNBC, September 19, 2019.
225 International Energy Agency, *Global EV Outlook 2020*, June 2020, at page 63.
226 FDG Electric Vehicles Limited, "FedEx Acquires 1,000 Chanje Electric Vehicles," Press Release, November 20, 2018.

EV Supply Chains and Critical Minerals

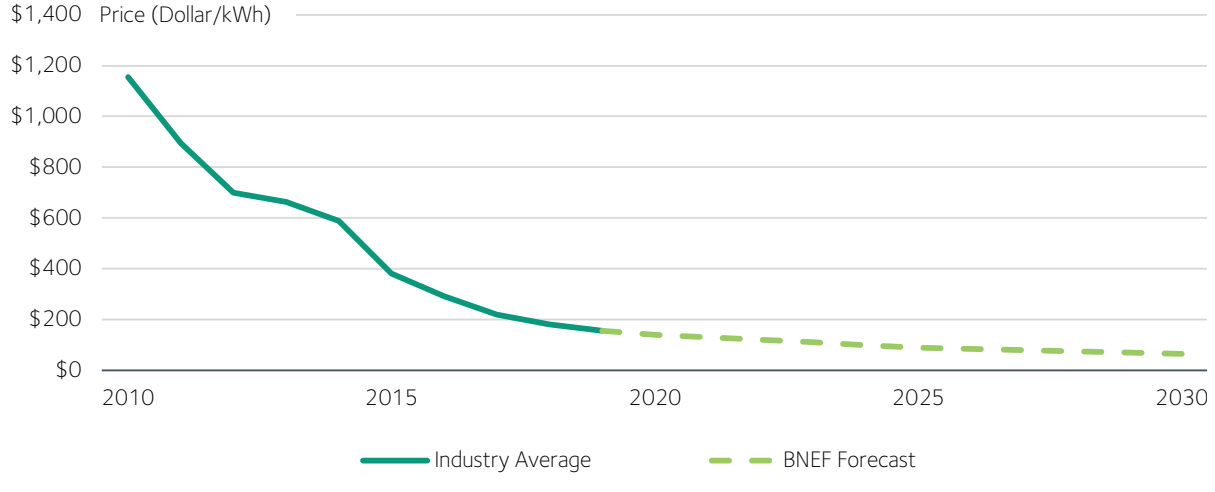
Beijing's significant investments and supportive policies may have propelled China to become a global EV leader, but that success would not have occurred without its strategic approach to developing the world's most robust EV supply chain.

Today, China exerts significant influence over nearly every step of the global EV supply chain, including the global mining and chemical processing of critical minerals; the production of anodes, cathodes, and lithium-ion cells for batteries; and the manufacturing of vehicles and their components.[227] If China continues to dominate the global EV supply chain, U.S. policymakers should worry about trading reliance on oil for dependence on minerals controlled by China.

One way Beijing controls the global supply chain is through its Belt and Road Initiative (BRI). Launched by Chinese Chairman Xi Jinping in 2013, the BRI attempts to centralize Chinese cities and companies in the global trading system, with a combination of infrastructure projects, bilateral trading deals, and propaganda, or "ideological work." The BRI also helps Beijing export and popularize Chinese technical standards: in 2017, for example, a Chinese and Indonesian firm agreed to build a high-speed rail connecting the capital Jakarta with the textile hub of Bandung. The line will be the first outside China that uses Chinese high-speed railway standards.[228] Normalizing and internationalizing Chinese standards will further impel companies to invest in and partner with China, just like the control of a mineral supply chain via BRI will facilitate further consolidation by Beijing. Though the coronavirus slowed down the BRI's expansion, China's relatively early recovery may give it a chance to exploit the current cheap cost of capital to refinance existing projects or invest in new

FIGURE 12

Electric Vehicle Battery Pack Prices



Source: Bloomberg New Energy Finance

227 David Coffin and Jeff Horowitz, "The Supply Chain for Electric Vehicle Batteries," United States International Trade Commission Journal of International Commerce and Economics, December 2018.

228 Cindy Silviana and Fanny Potkin, "Indonesian 'Belt and Road' high speed rail link expects $18 billion from satellite towns," Reuters, May 2, 2019; and "How will supply chains be affected by China's Belt and Road projects?" Reuters Events: Supply Chain, May 14, 2019.

ones.[229] As of February 2020, roughly 140 countries have signed on to the BRI.[230]

For decades, automakers invested heavily to refine the internal combustion engine, improving efficiency while maintaining performance.

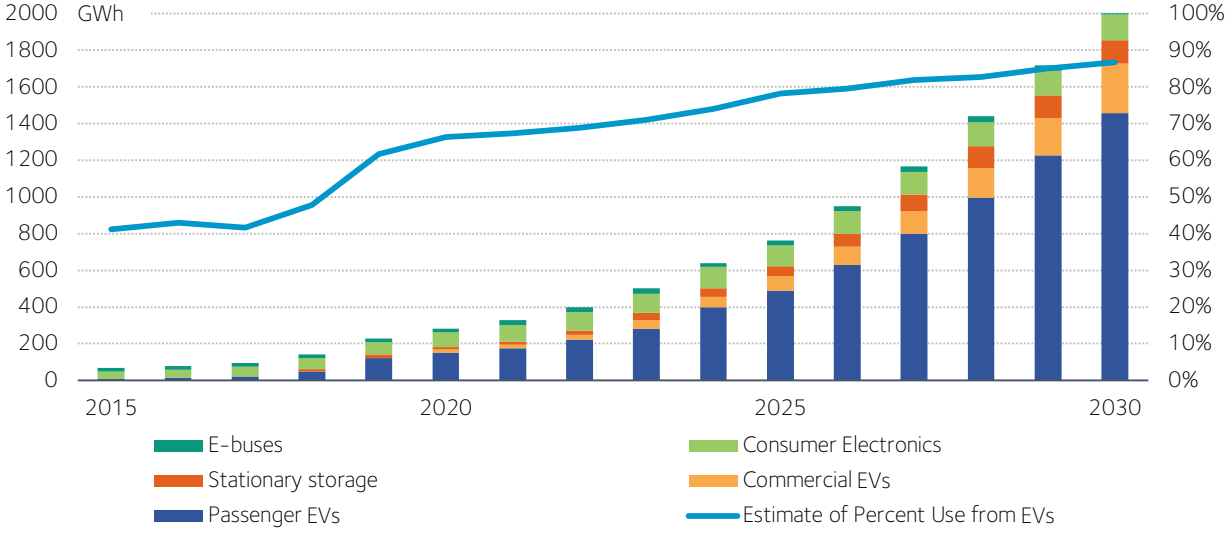
As EVs continue to gain greater market share, global automakers will increasingly compete not on internal combustion engines, but on lithium-ion battery technology.

Since the introduction of the first EV offerings in 2010, cost has been the most formidable obstacle to widespread adoption. At the time, the cost per kilowatt hour (kWh) for batteries was more than $1,000, and the first-generation Nissan LEAF had a range of only 74 miles.[231] The last several years, however, have seen enormous strides in battery technology, substantially lowering cost and increasing range potential. Today, battery prices have plummeted to around $150/kWh, and most EVs have a range that exceeds 200 miles.[232] This rapid progress has enabled the design and manufacture of EVs that can compete with the performance and convenience of gasoline-powered cars. Most analysts agree that once battery prices achieve $100/kWh, an EV's initial purchase price will reach price parity with internal combustion engine vehicles—possibly as soon as 2024.[233]

The EV industry, which includes electric buses and commercial vehicles, is expected to be the largest market for lithium-ion batteries—with EVs accounting for nearly 90 percent of demand by 2030.[234] Yet, while consumer electronics already depend on lithium-ion batteries, other emerging technologies—such as stationary energy storage for the grid—are also beginning to benefit from lower battery costs. If the United States does not secure or sufficiently diversify the global supply chains for lithium-ion batteries, that may jeopardize American ambitions for other transformative applications for battery use.

FIGURE 13

Annual lithium-ion battery demand



Note: SAFE analysis based on data from Bloomberg.

229 Frank Tang, "Coronavirus only a blip for China's belt and road plan, says former central bank chief," South China Morning Post, June 22, 2020.

230 China Power Team, "How will the Belt and Road Initiative advance China's interests?," Center for Strategic and International Studies, May 8, 2017.

231 Bloomberg New Energy Finance, "Battery Pack Prices Fall as Market Ramps Up with Market Average At $156/kWh in 2019," December 3, 2019.

232 Ibid.

233 Ibid.

234 SAFE analysis based on data from Bloomberg New Energy Finance *Electric Vehicle Outlook 2019*.

EV Battery and Component Manufacturing Shifting to China

Beijing will likely continue to lead in the development and refinement of lithium-ion batteries, giving it a significant advantage in twenty-first century transportation technologies. In 2019, China produced more than 70 percent of all lithium-ion batteries, while the United States produced less than 10 percent—a proportion expected to remain roughly the same in 2029.[235] Global EV battery manufacturing capacity stood at 455 gigawatt hours (GWh) in 2019, and could grow to more than 2,397 GWh by 2029.[236] In May 2020, there were at least 142 lithium-ion battery megafactories under construction—107 of which are, or will be, located in China.[237] Manufacturing scale offers one of the largest opportunities for a reduction in battery costs, and China will maintain this size advantage.

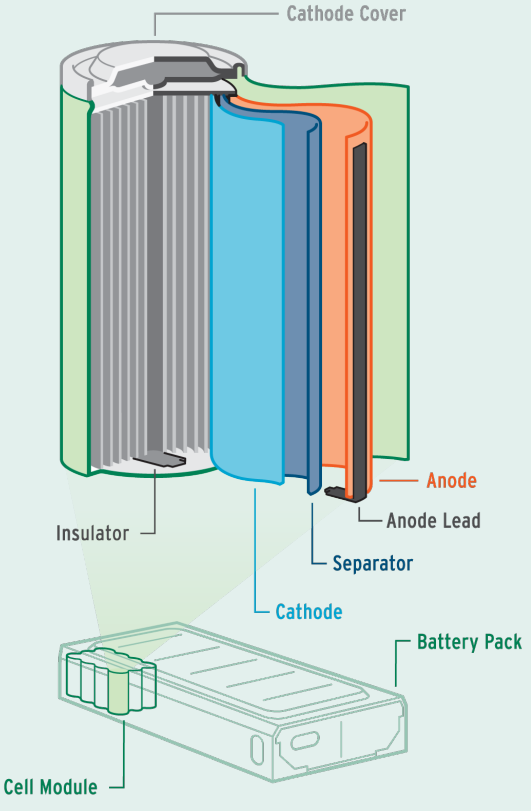
As one strategic minerals analyst told the U.S. Senate in 2019, "We are in the midst of a global battery arms race in which the United States is presently a bystander."[238]

Beijing also dominates the manufacturing of the components required to make batteries. A lithium-ion battery consists of an anode (negative electrode) and a cathode (positive electrode), usually made of graphite and a compound of lithium, respectively. Cathodes are one of the largest contributors to batteries' cost, and can account for more than 50 percent of the final price of the battery pack, depending on battery chemistry.[239] These cost ratios can vary widely, and depend largely on chemistry, cell type, and manufacturing costs. China currently produces more than 60 percent of the world's cathodes and 80 percent of anodes.[240]

LITHIUM-ION BATTERIES

The most basic component in the lithium-ion battery is the cell. Cells can be designed differently depending on the type of vehicle and performance needs (power vs. energy). Generally, a number of cells are assembled into a module, with each module containing its own control circuitry. Modules are then combined into larger battery packs.

CYLINDRICAL LI-ION CELL SECTION

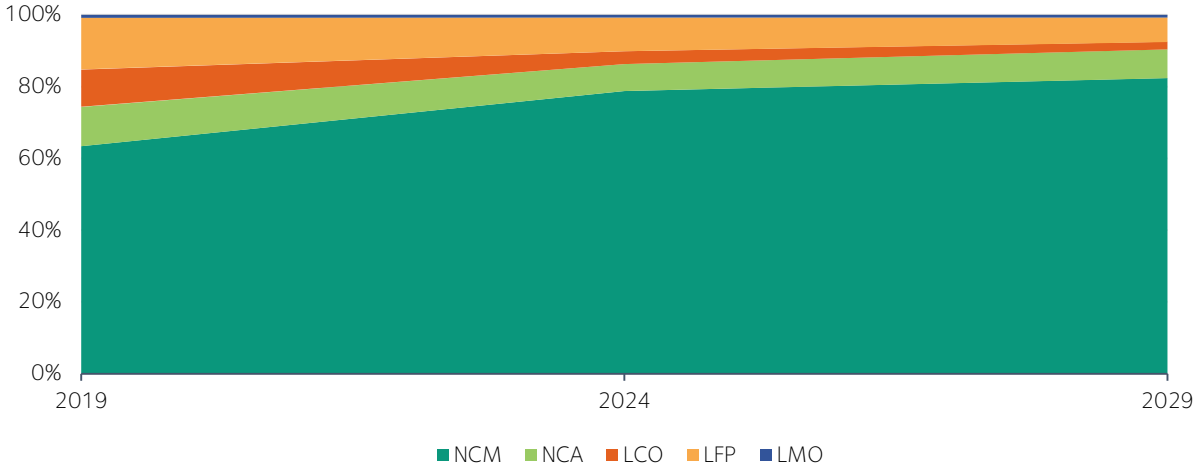


Source: Argonne National Laboratory

A variety of battery chemistries exist, each with its own advantages and disadvantages for power, energy, and safety. Nickel and cobalt are most often used with lithium to form cathodes. Lithium nickel-cobalt-manganese (NCM) are the most common today, accounting for roughly 60 percent of cathodes.[241] Nickel-cobalt-aluminum (NCA) and lithium iron-phosphate (LFP) are also regularly used.[242] LFP batteries, first popularized roughly a decade ago in Chinese EVs, tend to be cheaper than cobalt-containing battery

235 Benchmark Minerals Intelligence "China is Building one Battery Gigafactory a Week; The US One Every Four Months," May 2020.
236 Benchmark Mineral Intelligence, "Lithium-Ion Battery Megafactory Assessment," March 2020.
237 Simon Moores, "Written Testimony of Simon Moores: Full Committee Hearing on the Impact of COVID-19 on Mineral Supply Chains," Benchmark Mineral Intelligence and U.S. Senate Committee on Energy and Natural Resources, June 24, 2020.
238 Simon Moores, "Written Testimony of Simon Moores: Outlook for energy and minerals markets in the 116th Congress," Benchmark Mineral Intelligence and U.S. Senate Committee on Energy and Natural Resources, February 5, 2019.
239 Marcelo Azevedo et. al, "Lithium and Cobalt: A Tale of Two Commodities," McKinsey & Company, June 2018, at page 6; and Benchmark Mineral Intelligence, "Lithium-Ion Battery Megafactory Assessment," March 2020; and Billy Wu, Twitter post, June 3, 2020, 4:57 pm.
240 Data derived from Benchmark Mineral Intelligence.
241 Benchmark Mineral Intelligence, "Lithium-Ion Battery Megafactory Assessment," February 2020.
242 Ibid.

FIGURE 14
Global Production Capacity by Cathode Type, 2019 – 2029



Note: Lithium cobalt oxide (LCO) chemestries are largely used for consumer electronics.
Source: Benchmark Mineral Intelligence

chemistries and are increasingly attractive because they do not rely on cobalt, a volatile commodity discussed below.[243] While automakers such as General Motors and Volkswagen generally use NCMs, China continues to develop LFPs, especially for its electric bus fleet.[244]

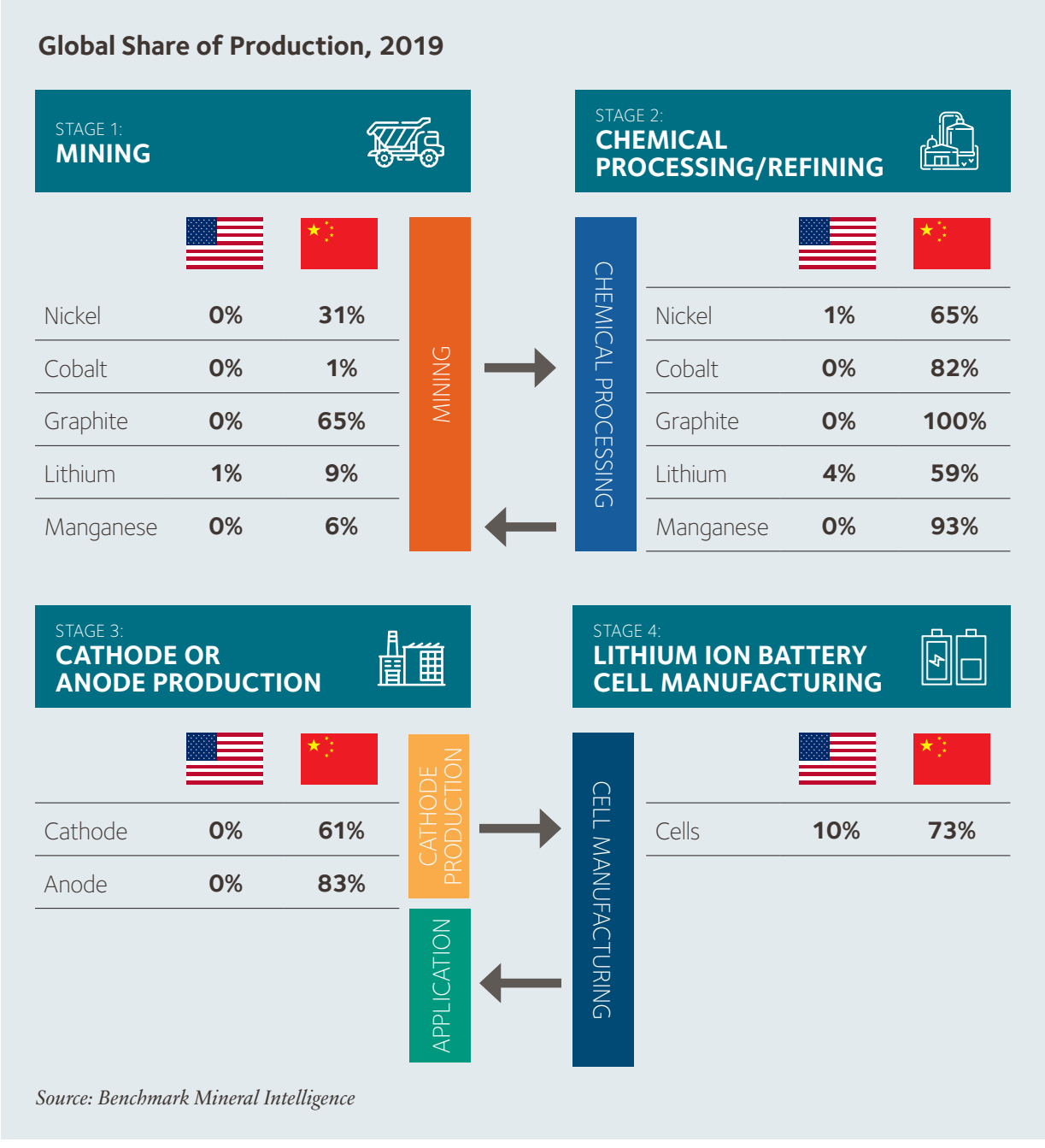
China produces roughly 75 percent of the world's permanent magnets that contain rare earth elements, another critical component for EV motors.[245] Beijing's dominance in permanent magnets threatens both the U.S. defense and automotive industries, as these magnets are used for a range of military applications, including missile defense systems.

Besides China, the United States also faces increased competition from Europe: in 2019 alone, the continent invested nearly $70 billion in EV technology.[246] Germany and France have created a battery consortium, to produce and recycle EV batteries, investing up to $6.7 billion in EV batteries to compete with the United States and China.[247] The EU has also funded lithium mining in Spain, Austria, and the Czech Republic to reduce European reliance on Chinese-dominated lithium supply chains.[248] The United States should ensure that it collaborates with European battery efforts, amidst healthy cooperation with European companies.

China's Mineral Advantage

Beijing has spent the last decade preparing for a global EV and battery revolution. It has focused on securing supplies of the raw materials required to fuel its rise, like cobalt, lithium, nickel, graphite, and rare earths. In October 2016, China's Ministry of Industry and Information Technology (MIIT) began implementing a strategic plan to deploy state-owned enterprises and other private firms to secure mineral resources in other countries, providing an opening for China to use state-backed funding to form relationships with companies or governments that needed capital.[249] The United States has ample deposits of several of these minerals. It has roughly one million tonnes of cobalt, mostly in Minnesota; and roughly 7 million tonnes of lithium, representing 8.5 percent of the world's total—higher than

243 Zhang Yan, Yilei Sun, and Brenda Goh, "Tesla in talks to use CATL's cobalt-free batteries in China-made cars – sources," Reuters, February 18, 2020.
244 Andrew J. Hawkins, "GM unveils a new electric vehicle platform and battery in bid to take on Tesla," The Verge, March 4, 2020; and ICC, "Tesla's competitor: Volkswagen start using NCM811 batteries for EVs," March 18, 2020; and Maya Xiao, "China's Electric Bus Market Dominance Driving Demand for Lithium-Iron-Phosphate Batteries," Interact Analysis.]
245 Marc Humphries, *Critical Minerals and U.S. Public Policy*, Congressional Research Service, June 28, 2019, at page 36.
246 William Todts, "Can Electric Cars Beat the COVID Crunch? The EU Electric Car Market and the Impact of the COVID-19 Crisis," Transport & Environment, May 2020, at page 12.
247 Foo Yun Chee, "Exclusive: EU Must Engage in Lithium Standards or Lose to China, EU's Breton Says," Reuters, June 18, 2020; and Carrie Hampel, "Start of Saft Battery Cell Pilot Production in France," ElectriveDotCom, January 30, 2020.
248 Anuradha Ramanathan, "Creation of Europe's Battery Industry in Full Swing," Argus Media Group, June 22, 2020.
249 U.S. Geological Survey, *Mineral Commodity Summaries 2020*, January 31, 2020, at pages 51 and 99.



Source: Benchmark Mineral Intelligence

both Australia and China.[250] The United States has an estimated 2.7 million tons of rare earths.[251] The problem is not the United States', lack of natural reserves, but that U.S. complacency allowed Beijing to dominate the global supply chains of the minerals crucial for an EV future.

Lithium

Beijing maintains a firm grip on the lithium industry.[252] Lithium appears naturally in either mineral (spodumene) or salt form (brine pools) and can also be found embedded in hard rock. Most of the world's lithium supply comes from seven mineral and five brine operations in Australia, Chile, Argentina, and China, though the U.S. Geological Survey (USGS) identified substantial lithium deposits in

250 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020, at pages 51, and 99.

251 Ibid., at page 133.

252 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020.

United States, Austria, Spain, Russia, among others.[253] Nearly 90 percent of lithium production occurs in Chile, Argentina, and Australia—with under 10 percent in China—yet nearly 60 percent of the processing occurs in China.[254] The United States accounts for less than 5 percent of both lithium mining and processing.[255] China maintains the world's fourth or fifth largest reserves of lithium.[256] While it is generally of lower quality than the type found in South America and Australia, growing demand over the coming decades will likely spur Beijing to invest more in domestic mining.[257]

Three main interlinking factors contribute to Beijing's domination of the lithium market. The first is its ownership of foreign mines. Over the last decade, Beijing has consolidated its influence: it now holds stakes in 67 percent of Chile's lithium output, 41 percent of Argentina's planned projects, and 61 percent of Australia's output.[258] These activities are largely coordinated through China's two major lithium producers, Ganfeng Lithium and Tianqi Lithium—two of the world's largest lithium companies.[259] Other Chinese companies, like Great Wall Motors, have also entered into agreements with foreign miners for long-term supplies of lithium.[260] The second is Beijing's ability to control, cajole, suppress, or expand domestic demand for lithium—by subsidizing its price, for example, or requiring companies to stockpile the mineral—depending on what it sees as best for the Party and the economy. The third is Beijing's skill in leveraging its stakes in foreign lithium companies *in combination with* domestic policy guiding Chinese lithium-buying firms. Further studies are required to uncover exactly how Beijing manipulates the global lithium market for its own interests.

Raw materials are key drivers of battery costs. Because the largest known reserves are often located in just a few countries, the transition to EVs raises concerns about dependence on China for resources such as lithium.[261] However, these concerns ignore a key feature of many of these minerals—and one of the main differences between lithium and petroleum—recyclability. Once an oil molecule is combusted in a vehicle's engine, its energy potential is gone—hence the term, "non-renewable resource." Lithium is more like a storage device. Once a vehicle battery has exceeded its useful life, it can be used for another application that does not have the performance requirements of automotive-grade batteries: like stationary power storage, for example.[262] When a battery finally is discarded, smelters can liquefy the metals and extract the lithium, which can then be reused.[263]

This reveals a fundamental reason that lithium dependence is unlike oil dependence: we do not deplete batteries as we drive, we deplete the energy stored within them. Batteries are like the engines in conventional vehicles: though their life span is finite, they last for many years.

Dependence on oil leaves the United States vulnerable because even a short-term supply disruption can stop the U.S. transportation system, while disruptions to lithium supplies would not hurt the mobility of the EVs already on the road.

This gives the U.S. economy an important layer of insulation from global commodity markets and underscores the inherent advantage of transportation electrification.

Because of Beijing's dominance over the lithium market, the recyclability of lithium, and the mineral's growing role in the future of transportation, the United States must push for more diversified lithium production and manufacturing. The largest untapped lithium deposits are in the politically unstable nation of Bolivia. It contains an estimated 25 percent of the world's lithium, including the salt pan Salar de Uyuni, believed to be the world's largest lithium deposit.[264] In February 2019, Le Paz selected a Chinese consortium to partner with it on a $2.3 billion lithium deal. But after a November 2019 coup, Bolivia's new government cast doubts on the partnership, and it is unclear whether Le Paz will allow China, the United States, or Germany to mine its lithium in the near term.[265] The United States possesses 8.5 percent of global lithium reserves, but contributes less than two percent of the world's supply.[266] One reason for this

253 Ibid.
254 Ibid.; and Frik Els, "China's stranglehold on electric car battery supply chain," MiningDotCom, April 16, 2020; and Benchmark Minerals Intelligence.
255 Ibid.
256 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020., at page 98.
257 Hugo Brennan and Guo Yu, "China's lithium supply chain strategy," Verisk Maplecroft, March 26, 2018.
258 Foreign Policy, "Mining the Future: How China is Set to Dominate the Next Industrial Revolution," May 2019, at page 6.
259 Ibid., at page 7.
260 See, e.g., Adam Jourdan, "China's Great Wall Secures Lithium Supply with Pilbara Deal," Reuters, September 29, 2017.
261 Alex Adams, "The United States Lags On Critical EV Minerals Development," The Fuse, November 25, 2019.
262 Hauke Engel, Patrick Hertzke, and Giulia Siccardo, "Second-life EV Batteries: The Newest Value Pool in Energy Storage," McKinsey & Company, April 30, 2019.
263 Mitch Jacoby, "It's Time to Get Serious About Recycling Lithium-Ion Batteries," Chemical & Engineering News, July 14, 2019.
264 Matthew Eisler, "Bolivian Lithium: Why You Should Not Expect Any 'White Gold Rush' in the Wake of Morales Overthrow," The Conversation, November 15, 2019.
265 Daniel Ramos, "Bolivia Picks Chinese Partner for $2.3 Billion Lithium Projects," Reuters, February 6, 2019; and Adam Jourdan, "Exclusive: Bolivia's New Lithium Tsar Says Country Should Go It Alone," Reuters, January 15, 2020.
266 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020, at page 98.

is that U.S. brines have a relatively smaller concentration of lithium than deposits in Argentina and Chile. Further technological innovation could improve economic viability of U.S. lithium deposits.[267]

Cobalt

Cobalt was an overlooked commodity until the early aughts, with no futures trading market and very little investment.[268] But the value of cobalt grew in tandem with the EV industry.[269] Cobalt is crucial for EV batteries due to its heat-holding capacity. Cobalt's extraordinarily high resistance to heat allows batteries to sustain a charge without damaging the battery.[270] Cobalt also allows the battery to charge and discharge evenly over a longer time period than competing compositions, prolonging battery life.[271]

While China has vast domestic resources of some minerals, it lacks others. For example, China accounted for less than three percent of global cobalt production in 2008, and less than two percent of global cobalt production in 2019.[272] Beijing has therefore focused on developing a relationship with the Democratic Republic of the Congo (DRC), which holds more than half of all global cobalt reserves.[273] Over the last 15 years, China has invested billions in the country's infrastructure and in its copper and cobalt mines.[274] Such investments have facilitated Beijing's ability to work with industry and government officials to secure equity shares and majority stakes in many of the DRC's largest cobalt mines.[275]

China now owns eight of the largest 14 cobalt mines in the DRC, which account for nearly half the country's output.[276]

Today, China controls more than 80 percent of all cobalt processing, providing it significant influence over the global market.[277]

Programs now included in the Belt and Road Initiative, like Resource for Infrastructure (RFI) deals, helped Beijing expand its control over the DRC.[278] Common in the DRC, these RFI deals include offers from China to build hospitals, telecommunications networks, and provide other public infrastructure in exchange for a country's commercial product—in this case, copper, cobalt, and timber. Beijing does not classify the exchanges as commercial transactions. Instead, it claims to be merely exchanging public goods for commercial products. The DRC has lost billions of dollars on such deals.[279] Beijing routinely undervalues the DRC's resources and overvalues Chinese infrastructure projects. The most glaring example comes from 2007, when the two countries signed an initiative called Sicomines. The deal exchanged infrastructure products for future supplies of cobalt—which allowed Beijing to lock in at a far lower price for the element, in exchange for poor quality roads and infrastructure.[280] In addition, Chinese infrastructure projects mainly hire Chinese workers and use Chinese products, preventing many of the economic benefits from staying in countries like the DRC. Project delays of RFI deals or stoppages are also common.[281]

The DRC's poor rule of law and corruption has facilitated China's monopoly of cobalt.[282] In a particularly egregious example, in 2016 the state-owned China Molybdenum spent $2.65 billion to purchase a controlling stake in the Tenke Fungurume mine from the U.S. company Freeport McMoran.[283] The purchase of the mine represented the largest expenditure ever made in the Democratic Republic of Congo, and the sale alone accounted for more than one percent of the country's GDP that year. But China Molybdenum paid no taxes to the Congo on the purchase, reducing its cost.[284]

Congo mining reforms and the fall of the price of cobalt hurt Chinese companies. As of August 2020, cobalt traded at roughly $33,000 a tonne—down nearly a third from its

267 Teague Egan, "Beating China at the Lithium Game – Can the US Secure Supplies to Meet Its Renewables Targets?" Utility Dive, February 18, 2020.
268 Ibid.
269 Priscila Barrera, "How to Invest in Cobalt," Investing News, April 25, 2019.
270 Michael Lightfoot, "Three Steps to Clean Up Electric Vehicle Supply Chains," World Economic Forum, September 24, 2019.
271 Angela Chen, "Elon Musk wants cobalt out of his batteries – here's why that's a challenge," The Verge, June 21, 2018.
272 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020, at page 51; and *Mineral Commodity Summaries 2009*, January 29, 2009, at page 49
273 Ibid.
274 See, e.g., Foreign Policy, "Mining the Future: How China is Set to Dominate the Next Industrial Revolution," May 2019.
275 See, e.g., Jack Farchy and Hayley Warren, "China Has a Secret Weapon in the Race to Dominate Electric Cars," Bloomberg, December 2, 2018; and Foreign Policy, "Mining the Future: How China is Set to Dominate the Next Industrial Revolution," May 2019.
276 Ibid.
277 Frik Els, "China's Stranglehold on Electric Car Battery Supply Chain," MiningDotCom, April 16, 2020; and Benchmark Minerals Intelligence.
278 David Landry, "Sicomines Deal Offers Four Clear Resource-for-Infrastructure Lessons," Natural Resource Governance Institute, March 9, 2017.
279 Andoni Maiza Larrate and Gloria Claudio-Quiroga, "How to Avoid Flawed Minerals-for-Infrastructure Deals Like DR Congo and China's Sicomines Pact," Quartz, April 3, 2019.
280 See, e.g., Aaron Ross, "China's 'Infrastructure for Minerals' Deal Gets Reality-Check in Congo," Reuters, July 9, 2015.
281 Ibid.
282 Michelle Chen, "The Democratic Republic of Congo's Other Crisis," The Nation, January 25, 2019.
283 Anet Pinto and Denny Thomas, "Freeport to Sell Prized Tenke Copper Mine to China Moly for $2.65 billion," Reuters, May 9, 2016.
284 Kathleen Brophy, "DRC's Largest Mine was Just Sold. And DRC Got Nothing," Oxfam America, August 3, 2016.

peak in 2018.[285] But the importance of the DRC as it relates to cobalt is likely to rise: by 2045, as mines elsewhere dry up, the DRC might account for an even greater share of the global supply of cobalt. The United States, Canada, Australia, and others are attempting to revive old mines or expedite research into potential new mines for cobalt, but the sellable product from such ventures is not likely to arrive soon.[286]

The political, ethical, and public relations difficulties of mining in the Congo are immense. One of the world's poorest and most corrupt nations, more than five million people have died in a series of civil wars that have riven the nation since World War II.[287] Besides struggling with coronavirus, in June 2020, the DRC faced yet another outbreak of the deadly Ebola virus.[288] Investing in the DRC also poses reputational risks. Some of the DRC's mines reportedly use child labor to produce cobalt, causing concern amongst automakers.[289] Chinese companies, not bound by the Foreign Corrupt Practices Act, and operating under different ethical standards, can more easily secure cobalt supplies.[290]

Nickel

Nickel improves energy density and storage capacity in batteries, allowing EVs to travel further on a single charge.[291] Lithium Nickel-Manganese-Cobalt (NMC) batteries hold the largest market share amongst lithium-ion battery chemistries—almost all EV manufacturers use NMCs in one form or another.[292] The amount of nickel used in battery cathodes is projected to increase: for example, Volkswagen aims to increase the nickel intensity of its cathodes from 65 percent to 80 percent by 2021, while General Motors is also focused on developing batteries with higher nickel concentrations.[293]

Nickel is generally only found in concentrations of one to two percent, meaning that a large amount of material must be mined in order to produce significant quantities. But nickel projects are susceptible to large cost overruns, which could decrease investors' willingness to invest in new nickel mine projects.[294] Notable nickel producers include Indonesia, the Philippines, Russia, and Australia, which have laterites (nickel-bearing ores) resulting in a cheaper form of nickel, Nickel Pig Iron (NPI). While NPI is suitable for stainless steel production, it is not suitable for EV batteries. Lithium-ion batteries need high purity nickel, which is typically in the form of nickel sulfate. However, just a handful of sulfide deposits, such as those in Alaska or Quebec, make up one-third of the world's nickel resources.[295]

Because stainless steel represented roughly 70 percent of global nickel demand in 2019—with batteries accounting for four percent—stainless-steel producers have huge sway over the nickel market (regular steel is made almost entirely of iron). Chinese companies dominate the stainless-steel market, though often through NPI. In 2019, they produced more than 56 percent of the world's stainless steel.[296] The world's largest stainless-steel producer, Tsingshan Holding Group, controls roughly one-fifth of the market.[297]

Indonesia is the largest producer of nickel, accounting for nearly 30 percent of global production in 2019.[298] A longtime investor in the country, Tsingshan has close ties with Indonesia's President Joko Widodo. In January 2019, Tsingshan started building a lithium battery project in Indonesia, with cheaper funding via the Belt and Road Initiative.[299] In July 2019, Tsingshan's chairman Xiang Guangda met with Joko and discussed plans to expand the company's investment into his country to $15 billion. Several months later, Joko announced he would curb nickel ore exports—a move directly benefitting Tsingshan, the country's largest producer of NPI.[300] The company is building operations to produce non-NPI, high-purity nickel from laterite sources for EV battery use. The transformation from laterite to sulfate, however, has high monetary and environmental costs.[301]

Graphite

Roughly 90 percent of battery anodes are produced using graphite.[302] Its stable structure, low electrochemical reactivity, and thermal stability make it a reliable, safe, and low-cost

285 London Metal Exchange, "LME Cobalt: Price Graph," September 18, 2020.
286 Ed Crooks, "US, Canada and Australia Join Forces to Tackle Metal Shortage Risk," Financial Times, June 11, 2019; and Natalie Sherman, "The Precious Metal Sparking a New Gold Rush," BBC News, July 26, 2018.
287 BBC News, "Q&A: DR Congo conflict," November 20, 2012.
288 World Health Organization, "New Ebola Outbreak Detected in Northwest Democratic Republic of the Congo; WHO Surge Team Supporting the Response," June 1, 2020.
289 See, e.g., Henry Sanderson, "Congo, Child Labour and Your Electric Car," Financial Times, July 7, 2019.
290 Chinwe Esimai, "Chinese Investments in Africa: Four Anti-corruption Trends to Watch," Knowledge@Wharton, September 19, 2019.
291 See, e.g., Nickel Institute, "Nickel in batteries," Webpage.
292 Ankit Gupta and Nikhil Paranjape, "Lithium Ion Battery Market by Chemistry, 2020-2026," Global Market Insights, May 2020.
293 Benchmark Minerals Intelligence, "Cathode Market Assessment," March 2020, at page 3.
294 Ibid.
295 Anthony Milewski, "Nickel – The often Forgotten Battery Metal," Benchmark Minerals, January 28, 2019.
296 International Stainless Steel Forum, "Stainless Steel in Figures 2020," 2020, at page 4.
297 Alfred Cang et al., "A Chinese Steel Giant is Upsetting the Global Nickel Market," Bloomberg News, November 1, 2019.
298 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020.
299 Ed Davies and Gayatri Suroyo, "Indonesia Nickel Boom on Track to Overshadow Palm Oil: Investment Chief," Reuters, March 27, 2019.
300 Mai Nguyen and Wilda Asmarini, "Miners Welcome Indonesian Export Ore Ban, Plan Smelting Expansion," Reuters, September 11, 2019.
301 Anthony Milewski, "Nickel – The often Forgotten Battery Metal," Benchmark Minerals Intelligence, January 28, 2019.
302 Benchmark Minerals Intelligence, "Graphite + Anodes 2019: Key Talking Points," Webpage, November 15, 2019.

option. The graphite component of anodes is either flake or synthetic.[303] Flake graphite must undergo intense physical milling and chemical purification to produce the graphite used in anodes. Synthetic graphite, or artificial graphite, is made by processing carbon at extremely high temperatures.[304] While around 59 percent of graphite for anodes in 2019 was flake graphite, new facilities focus on producing anodes from synthetic graphite.[305] Beijing dominates the graphite market: in 2019, 65 percent of flake graphite was mined and 100 percent was refined in China.[306]

Flake graphite is safe to use, but it's incredibly dangerous to mine.[307] The leakage of the chemicals used to treat and prepare graphite for commercial use can wreak havoc on water tables and on the health of nearby people. Residents of a Chinese village with a graphite factory complained that the dust got stuck in their teeth—inhaling commercially treated graphite dust can cause lung damage and heart attacks.[308] For price and safety reasons, Beijing is shifting away from graphite mining: large graphite deposits in Madagascar, Mozambique, Namibia, and Tanzania have been in development over the last few years.[309] The Australia-based Syrah Resources Mozambique mine, reportedly the largest graphite deposit in the world, began producing high-grade graphite in 2019.[310]

Synthetic graphite is more expensive, but it is both more efficient and safer to produce.[311] There is no graphite mining in the United States. Moreover, there is both limited synthetic graphite production in the United States, and limited reliable information about the industry.[312] As demand continues to grow for anodes, and processing innovation drives down the price of producing synthetic graphite, the United States may find new opportunities in the synthetic graphite market.

303 Jakob Asenbauer et al., "The Success Story of Graphite as a Lithium-ion Anode Material – Fundamentals, Remaining Challenges, and Recent Developments Including Silicon (Oxide) Composites," Royal Society of Chemistry, April 29, 2020.
304 Peter Kurzweil, "Electrochemical Double-layer Capacitors," in *Electrochemical Storage for Renewable Sources and Grid Balancing*, 2015, at page 354.
305 Benchmark Minerals Intelligence, "Anode Market Assessment," January 2020.
306 MiningDotCom Editor, "CHART: China's Grip on Battery Metals Supply Chain," MiningDotCom, May 7, 2020.
307 Gilpin R. Robinson, Jr., Jane M. Hammarstrom, and Donald W. Olson, "Graphite," in *Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply*, 2017, at page J2.
308 See, e.g., Peter Whoriskey, "In Your Phone, In Their Air," The Washington Post, October 2, 2016.
309 Ibid. and USGS, *Mineral Commodity Summaries 2020*, January 31, 2020, at page 72.
310 Mining Technology, "Balama Graphite Project,"; and Syrah Resources, "Balama Overview."
311 Gilpin R. Robinson, Jr., Jane M. Hammarstrom, and Donald W. Olson, "Graphite," in *Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply*, 2017, at page J2; U.S. Geological Survey, *Mineral Commodity Summaries 2020*, U.S. Department of the Interior, 2020, at page 72; and Amanda Kay, "What is Synthetic Graphite?," Investing News Network, July 31, 2018.
312 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020, at page 73.

Rare Earths

Unlike the other minerals mentioned above, rare earths are not used in EV batteries. Rather, they are crucial for permanent magnets, which are used in EV motors, military technologies, and nearly all consumer electronics.[313] Despite their name, rare earths are abundant in both the earth's crust and the ocean's floor, but are seldom found in pure form. China holds an estimated 40 percent of the world's reserves—by far the most of any country.[314] It also produces more than 60 percent of their mined global supply, and holds more than 85 percent of their processing capacity.[315] Brazil and Vietnam are the other major holders of global reserves.[316]

While there are 15 rare earth elements, two are specifically used for EV motors—neodymium and dysprosium.[317] More than 90 percent of EVs and hybrids use rare earth-based magnets in their motors.[318] EV motors typically feature powerful neodymium-iron-boron magnets, the strongest magnets produced today.[319] Motors use the torque created by these magnets to power the wheels of EVs. The downside of neodymium magnets is that they lose their magnetism between 140°F - 176°F. Substituting a small amount of neodymium for dysprosium increases operating temperatures to above 320°F, and adds higher resistance to demagnetization.[320]

Beijing has a long and well-publicized history of dominance over the rare earth market, mostly because of its low labor and processing costs, and lack of environmental regulations. "The Middle East has oil, China has rare earths," China's then leader, Deng Xiaoping, quipped during a 1987 tour of a rare earth deposit in the country's Inner Mongolia region.[321] In the 1990s, China began flooding the rare earth minerals market with low-priced minerals to drive out other miners.[322] Although the United States, Canada, and

313 See, e.g., Lucy Hornby and Henry Sanderson, "Rare Earths: Beijing Threatens a New Front in the Trade War," Financial Times, June 3, 2019.
314 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020, at page 133.
315 Ibid.; and Tom Daly, "China raises annual rare earth output quotas to record high," Reuters, November 8, 2019.
316 Ibid.; and See, e.g., Bill Whitaker, "Why the U.S. is Missing Out on the Race to Mine Trillions of Dollars Worth of Metals from the Ocean Floor," CBS News 60 Minutes, November 17, 2019.
317 Note: Praseodymium and terbium are also used. See, e.g., Lucy Hornby and Henry Sanderson, "Rare Earths: Beijing Threatens a New Front in the Trade War," Financial Times, June 3, 2019.
318 Ibid.
319 Hongyue Jin et al., "Life Cycle Assessment of Neodymium-Iron-Boron Magnet-to-Magnet Recycling for Electric Vehicle Motors," Environmental Science and Technology, February 27, 2018.
320 Edison Group, "Electric Vehicles and Rare Earths," Webpage, January 29, 2019.
321 Yoichi Funabashi, "The Mideast Has Oil, China Has Rare Earths," Japan Times, August 9, 2019.
322 Wayne Morrison and Rachel Tang, *China's Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States*, Congressional Research Service, April 30, 2012, at page 8.

Australia have untapped rare earth deposits, many miners cannot compete with China's prices.[323] Further complicating the development of mining or manufacturing capabilities in other countries are the toxic and sometimes radioactive hazards associated with the mining and processing of rare earths. Rare earth minerals are processed primarily from ores containing uranium and thorium. Dealing with that waste can be prohibitively expensive, undermining potential rare earths projects.[324]

What is more concerning about the Chinese dominance of the rare earth market is Beijing's ability to use rare earths as a political weapon. By 2010, China was producing the vast majority of the world's rare earth supply, and Japan was its largest customer. Amidst geopolitical tensions between the two countries, Beijing issued a de facto ban on exports. This hurt Japan—in the second half of 2010, the country saw a stunning 70 percent drop of rare earth imports from China compared to a year earlier.[325] Beijing further damaged global rare earth producers when, after keeping prices artificially high, it relaxed restrictions in 2011, devastating the lone U.S. producer Molycorp Minerals, LLC, which had inadequately prepared for lower prices. Beijing has also placed export quotas on rare earth minerals mining and separation for the last several years, signaling their ability and willingness to manipulate prices.[326] These quotas allow China to continue to support its domestic mining, processing, and manufacturing industries by controlling prices. In May 2019, China's current leader Xi Jinping visited a Chinese rare earths magnet-maker and gave a speech about self-sufficiency in rare earths, rattling global markets—investors had not forgotten what happened to Japan. A few days later, China's National Development and Reform Commission threatened to weaponize rare earth exports over the trade dispute with the United States, by asking, "Will rare earths become China's counter-weapon against the United States unwarranted suppression?"[327] The United States relies on China for approximately 80 percent of rare earth supplies.[328] Widespread commercialization of EVs will only make the United States more susceptible to China's threats.

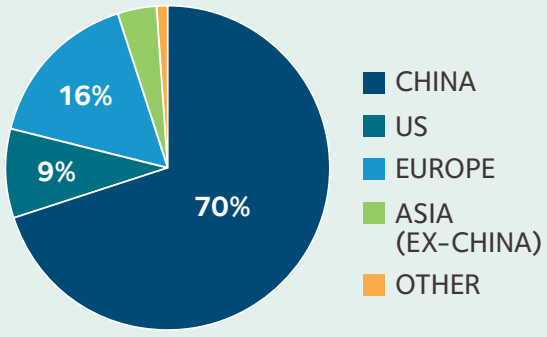
By creating an ecosystem of minerals production and processing, battery manufacturing, and vehicle manufacturing, Beijing has captured significant influence over the global EV supply chain.

The United States, meanwhile, remains import dependent on many minerals and, even when the United States can procure the minerals, China largely controls the processing facilities. According to U.S. Department of Interior (DOI) data, the United States is 100 percent import dependent on 14 critical minerals, and heavily reliant on imports for other key minerals.[329] Given the nature of China's economic system, if U.S.-China relations deteriorated sharply, Beijing may order Chinese-backed companies to manipulate mineral supplies, advancing Chinese state interests at the expense of the United States.

323 USGS, *Mineral Commodity Summaries 2020*, January 31, 2020, at page 133.
324 See, e.g., Environmental Protection Agency, "TENORM: Rare Earths Mining Wastes," Webpage.
325 Amy King and Shiro Armstrong, "Did China Really Ban Rare Earth Metals Exports to Japan?" East Asia Forum, August 18, 2013.
326 Tom Daly, "China Raises Annual Rare Earth Output Quotas to Record High," Reuters, November 8, 2019.
327 Lucy Hornby and Archie Zhang, "China's State Planner Suggests Using Rare Earths in US Trade War," Financial Times, May 29, 2019; and See, e.g., Martin Ritchie and Winnie Zhu, "China Stokes Rare Earths Concerns With Possible Export Controls," Bloomberg, June 4, 2019.
328 See, e.g., Martin Ritchie and Winnie Zhu, "China Stokes Rare Earths Concerns With Possible Export Controls," Bloomberg, June 4, 2019.
329 Marc Humphries, *Critical Minerals and U.S. Public Policy*, Congressional Research Service, June 28, 2019, at page 20.

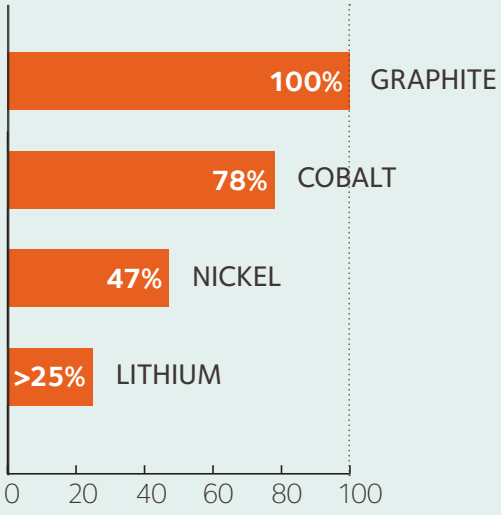
THE GLOBAL EV SUPPLY CHAIN

Forecast EV Battery Megafactory Capacity (GWh), 2029

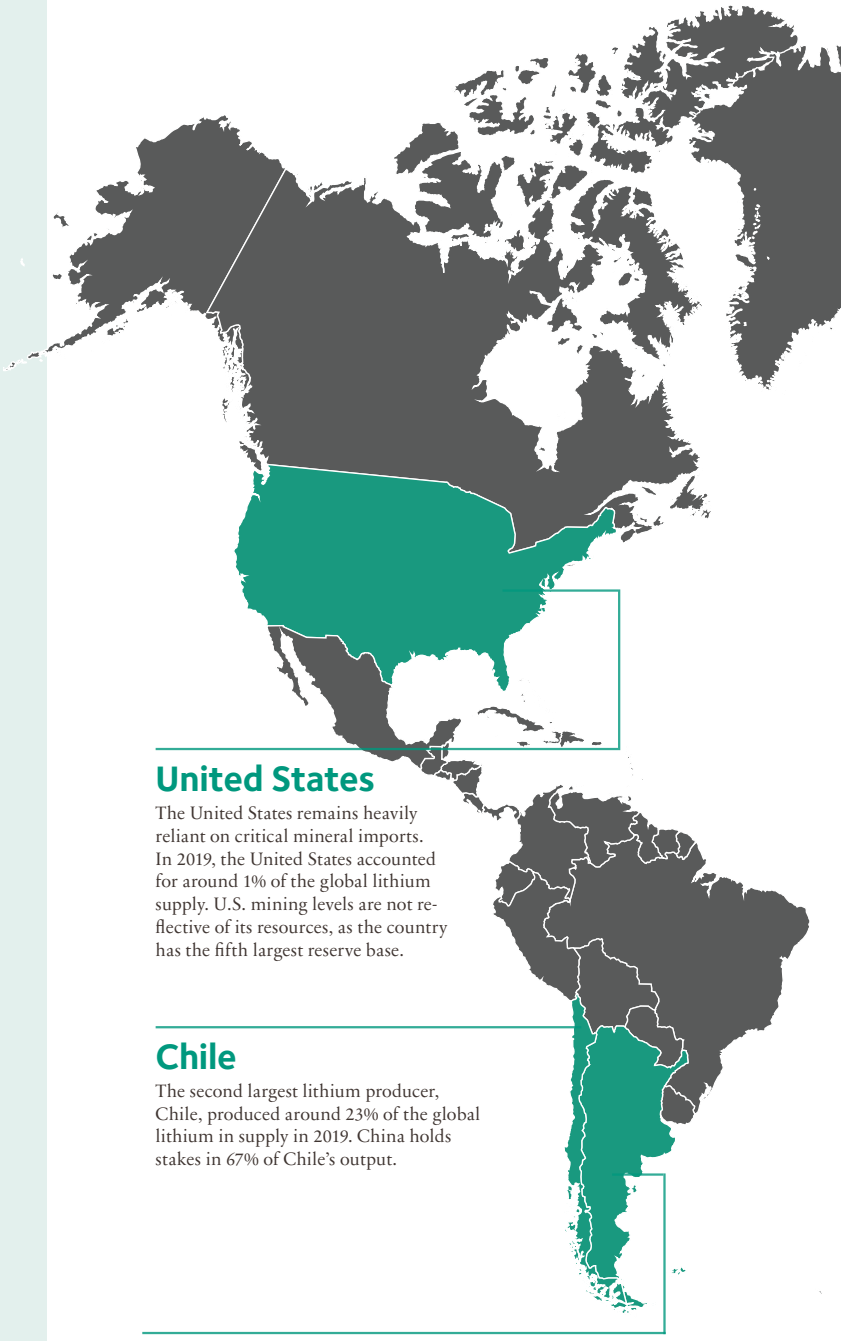


Source: Benchmark Mineral Intelligence

Estimated 2019 U.S. Net Import Reliance, Select Minerals



Source: U.S. Geological Survey



United States

The United States remains heavily reliant on critical mineral imports. In 2019, the United States accounted for around 1% of the global lithium supply. U.S. mining levels are not reflective of its resources, as the country has the fifth largest reserve base.

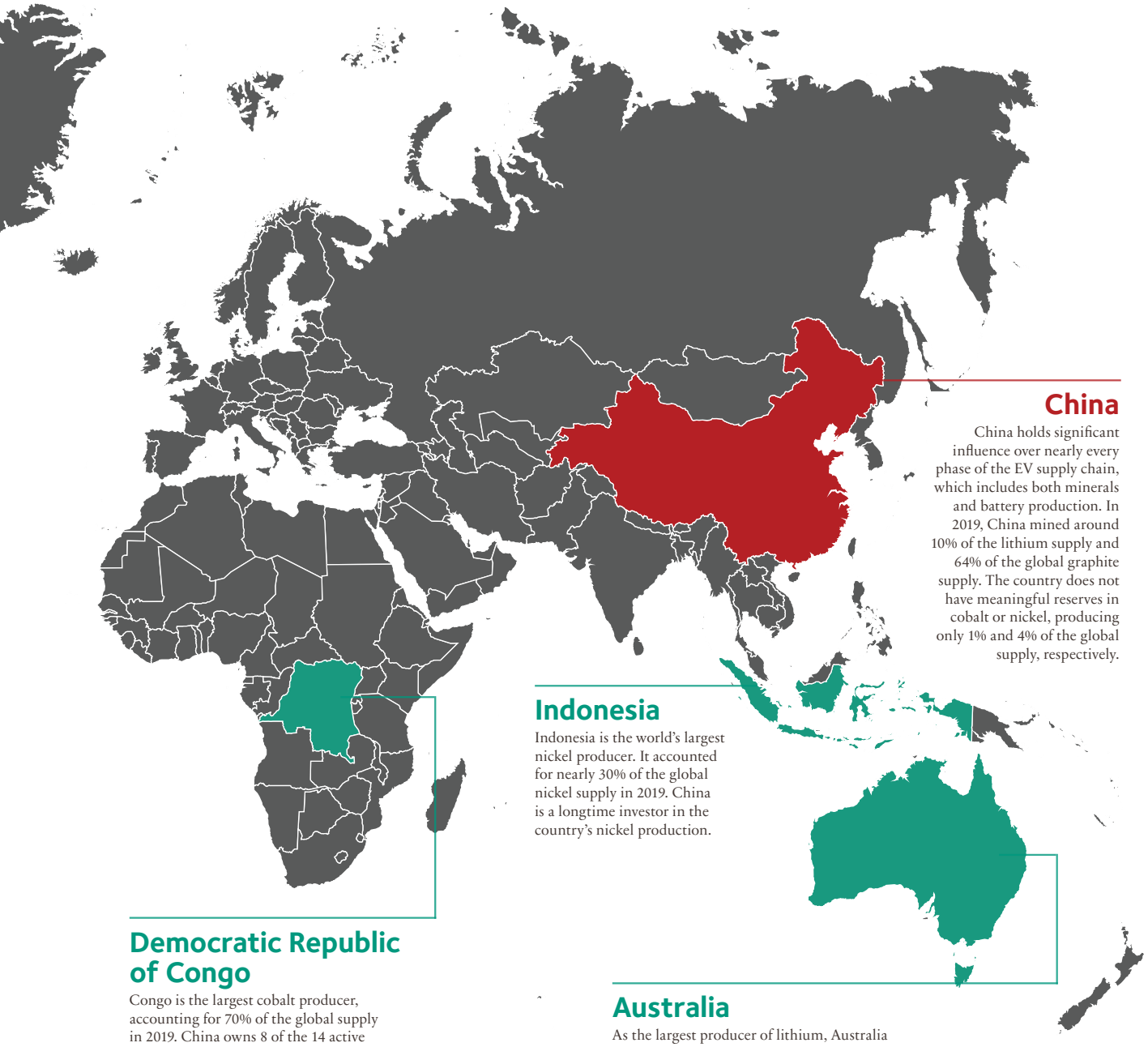
Chile

The second largest lithium producer, Chile, produced around 23% of the global lithium in supply in 2019. China holds stakes in 67% of Chile's output.

Argentina

In 2019, Argentina produced approximately 8% of the global lithium supply, becoming the fourth largest lithium producer. China holds stakes in 41% of the country's planned projects.

The global EV supply chain is heavily influenced by Beijing. While it is rich in certain minerals, China does not have sufficient domestic resources for all battery minerals. Instead, Beijing has deployed state-owned enterprises and other private firms to expand mining operations overseas, allowing China to capture significant control over all stages of the battery supply chain. The United States remains mostly dependent on imports of raw minerals and chemicals.



China

China holds significant influence over nearly every phase of the EV supply chain, which includes both minerals and battery production. In 2019, China mined around 10% of the lithium supply and 64% of the global graphite supply. The country does not have meaningful reserves in cobalt or nickel, producing only 1% and 4% of the global supply, respectively.

Indonesia

Indonesia is the world's largest nickel producer. It accounted for nearly 30% of the global nickel supply in 2019. China is a longtime investor in the country's nickel production.

Democratic Republic of Congo

Congo is the largest cobalt producer, accounting for 70% of the global supply in 2019. China owns 8 of the 14 active cobalt mines, controlling nearly half of the country's output.

Australia

As the largest producer of lithium, Australia mined 54% of the global supply in 2019. China holds stakes in 61% of the country's lithium output. Australia also has minor contributions to cobalt and nickel mining: 4% and 7% respectively.

The AV and 5G Industries

EVs are not the only innovations that could revolutionize the transportation sector. Autonomous vehicles (AVs) and intelligent transportation systems utilizing 5G telecommunications technology could both radically transform how people and goods move through society.

The countries that lead in the development and integration of EVs, AVs, and 5G will significantly influence the global automotive industry, and reap the economic benefits which will result from a new mobility paradigm.

Governments, automakers, technology giants, wireless providers, rideshare companies, venture capitalists, and startups are all investing heavily in these disruptive technologies.

The United States leads in AV technology—but over the last several years, Beijing has redoubled its efforts to become an influential player in the AV market.

Beijing has sponsored new enterprises by its national champions, innovated in supporting industries such as 5G, and offered strong policy and financial support. Indeed, the United States is falling behind China in deploying 5G networks. Moreover, the international influence of the Beijing-backed telecommunications giant, Huawei, means the United States risks ceding leadership on crucial technologies to China.

The Nascent AV Industry

AV technology offers several important societal benefits, including reduced road fatalities, economic growth, and improved access to mobility for underserved populations. In the United States alone, the annual benefits from the widespread adoption of AVs could reach nearly $800 billion annually by 2050.[330] AVs could also accelerate the adoption of EVs, which use cheaper, more predictably-priced electricity instead of relatively expensive and unstable gasoline.

By eliminating inefficiencies in how vehicles are owned, used, sized, and fueled, AVs—when paired with EVs and shared rides—could fundamentally reshape both the transportation system and mobility. The current transportation system is hugely inefficient: the average household vehicle, for example, spends 95 percent of its time parked.[331] The majority of vehicle trips also feature just one or two passengers, among several empty seats.[332] Poorly-designed road infrastructure, and the difficulty of finding parking spaces, often lead to system congestion, and wasted time and fuel.[333] Most of the fuel burned in motor vehicles is lost to friction and engine inefficiencies. Even the fuel used for forward motion mostly propels the vehicle, not its passengers. Moreover, time spent driving vehicles, especially when commuting, is less productive than time in an office, at home, or as a vehicle passenger. Residents of Beijing, for example, spend an average of 1.3 hours commuting every day.[334]

AV technology can address these inefficiencies while also providing safe, reliable, and on-demand transportation. This shift could change the economic calculus of personal vehicle ownership, modes of transportation, and vehicle technology platforms. However, even with a compelling economic rationale and consumer value proposition, the need for further technological development and the lack of a comprehensive regulatory framework could delay the deployment of AVs. Given the potential for significant societal benefits, U.S. policymakers and regulators should prioritize removing the regulatory obstacles hindering AV deployment.

330 See, e.g., Securing America's Future Energy, "America's Workforce and the Self-Driving Future," June 2018, at page 8.

331 See, e.g., Jim Motavalli, "Who Will Own the Cars That Drive Themselves?," The New York Times, May 29, 2020; and Lawrence Burns, et al., "Transforming Personal Mobility," The Earth Institute, January 27, 2013.

332 See, e.g., FHWA, "Average Vehicle Occupancy Factors for Computing Travel Time Reliability Measures and Total Peak Hour Excessive Delay Metrics," April 2018.

333 See, e.g., Kevin McCoy, "Drivers Spend an Average of 17 hours a year searching for parking," USA Today, July 12, 2017.

334 Luca Pizzuto, Christopher Thomas, Arthur Wang, and Ting Wu, "How China will help fuel the revolution in autonomous vehicles," McKinsey&Company, January 25, 2019.

AV Technology in the United States

Nearly every major automaker has announced a program to develop AVs, although their timelines for commercialization vary. The success of AVs will likely depend on the ability of automakers and their suppliers to successfully integrate a suite of components—like sensors to map the vehicles' surroundings, including lidar, radar, and cameras—absent from most non-autonomous vehicles.[335] AVs compile information from these components in real time, and make driving decisions using software, electronics, and specialized processors. This allows AVs to identify road signs, pedestrians, vehicles, and detect objects similar to how a human driver perceives the world around it. Besides anticipating pedestrian, driver, and cyclist behavior, AV software must also react to unexpected events. Improving the software to a level that matches human drivers—and then proving that it is as good—has hindered widespread commercialization of AVs.[336]

U.S. companies that prioritize AVs have attracted an estimated $11.9 billion in investment since 2014.[337]

The industry leader is Waymo, a subsidiary of Google's parent company Alphabet. Waymo's autonomous vehicle project began in 2009; by December 2019, Waymo had driven more than 20 million miles on public roads in 25 different cities.[338] Several other major corporations are also investing significantly to develop AVs. In 2016, General Motors spent nearly $1 billion to purchase the self-driving car startup Cruise Automation; Ford invested more than $1 billion in the AV startup Argo AI;[339] while Uber acquired Otto, a self-driving truck startup focused on the movement of freight.[340] Uber's AV program also benefited from its poaching of nearly 40 researchers and scientists from Carnegie Mellon University in 2015.[341]

It is difficult to predict the timeline for widespread AV commercialization. But some of AVs' many transformative applications are already used today. In late 2018 Waymo began operating a self-driving taxi service called Waymo One in Chandler, Arizona, and logged more than 100,000 trips in its first twelve months.[342] Waymo introduced a "rider only" option without human safety drivers—not the industry norm for early testing—and partnered with Lyft to provide robotaxi services to ridehailing customers in the area.[343] Uber is developing its own AVs, which it is testing on the streets of Pittsburgh and San Francisco, with plans to expand to Toronto, Dallas, and Washington DC.[344] The AV start-up Voyage is testing its self-driving vehicles inside Florida and California's retirement communities, providing new mobility opportunities for older adults and showing the potential for AVs to dramatically improve the lives of communities underserved by our current transportation system.[345] Another AV start-up, Nuro, will deploy self-driving delivery pods, and has partnered with the supermarket chain Kroger to deliver groceries in Scottsdale, Arizona and Houston, Texas.[346] The delivery applications of AVs are not limited to groceries: with the start-up Embark, Amazon is testing self-driving trucks on the I-10 highway.[347] Waymo also began testing self-driving trucks in Texas and New Mexico in early 2020.[348]

Commercial vehicles like trucks and buses are a more natural fit for automation than passenger cars. Trucks often travel limited-access roads, such as the Interstate Highway System, which present a less complex environment than urban roads. This reduces the technical requirements to provide high degrees of automation.[349] China is also developing autonomous trucks, most notably through TuSimple, a company which operates in both China and the United States.

While U.S. companies have made great progress, the AV market faces many uncertainties and challenges that must be overcome for the United States to maintain its leadership position. One of the biggest challenges is the lack of consistent AV regulation. While the U.S. Department of Transportation (USDOT) has released AV road-testing guidelines, there is no comprehensive regulatory framework for AVs. Instead, states

335 See, e.g., Toyota, "Elements of Automated Driving," Webpage.
336 See, e.g., Neal Boudette, "Despite High Hopes, Self-Driving Cars Are 'Way in the Future'," The New York Times, July 17, 2019.
337 See, e.g., The Economist, "Chinese firms are taking a different route to driverless cars," October 12, 2019.
338 Waymo, "Our Journey," Webpage, 2019-2020; and See, e.g., Kyle Wiggers, "Waymo's autonomous cars have driven 20 million miles on public roads," VentureBeat, January 6, 2020.
339 See, e.g., Bill Vlasic and Mike Isaac, "General Motors to Buy Cruise Automation in Push for Self-Driving Cars," The New York Times, March 11, 2016; and Alexandria Sage, "Ford to invest $1 billion in autonomous vehicle tech firm Argo AI," Reuters, February 10, 2017.
340 See, e.g., Bernie Woodall, "Uber buys self-driving truck startup Otto; teams with Volvo," Reuters, August 18, 2016.
341 See, e.g., Mike Ramsey and Douglas MacMillan, "Carnegie Mellon Reels After Uber Lures Away Researchers," The Wall Street Journal, May 31, 2015.
342 See, e.g., Keith Naughton, "Waymo's Autonomous Taxi Service Tops 100,000 Rides," Bloomberg, December 5, 2019.
343 Ibid.
344 See, e.g., Michael Laris, "Uber is bringing its testing of self-driving vehicles to D.C. streets," The Washington Post, January 23, 2020; and Kirsten Korosec, "Uber Self-Driving Cars are Back Testing on San Francisco Streets," TechCrunch, March 10, 2020.
345 See, e.g., Cade Metz and Erin Griffith, "This Was Supposed to Be the Year Driverless Cars Went Mainstream, The New York Times, June 26, 2020.
346 See, e.g., Andrew Hawkins, "Nuro's robot delivery cars are coming to Houston, Texas," The Verge, March 14, 2019; and Andrew Hawkins, "Two ex-Google engineers built an entirely different kind of self-driving car," The Verge, January 30, 2018.
347 See, e.g., Lora Kolodny, "Amazon is hauling cargo in self-driving trucks developed by Embark," CNBC, January 30, 2020.
348 See, e.g., Neha Malara, "Waymo to test autonomous trucks, vans in Texas and New Mexico," Reuters, January 23, 2020.
349 Chuck Tannert, "Autonomous trucks will haul your stuff before you ride in a self-driving car," Ars Technica, May 29, 2018.

and cities adopt legislation to attract AV companies, creating a patchwork of legislation that is inconsistent throughout the country.[350] This forces AV companies to develop their technology according to potentially competing regulations, slowing industry development.

The most important infrastructure required for AV commercialization may be 5G. 5G, and the low latency it provides, will permit real-time vehicle-to-everything (V2X) communication, enabling AVs to communicate with other vehicles and city infrastructure, like traffic lights, smoothing traffic flow.[351] A developed 5G network, while not necessary for AV deployment, may support the widespread deployment of AVs (and a 5G network will facilitate connectivity among cars, trucks, buses, and traffic signals even before the commercialization of AVs). The United States is falling behind China in the 5G rollout: losing to China could present serious consequences, as discussed below.

China's AV Industry

Before 2016, AV development in China was limited to several companies, most of which were state-owned. The state-owned automaker SAIC, for example, announced a plan to develop self-driving cars in 2013.[352] Beijing first identified the AV sector as critical in its 2015 *Made in China 2025* document. The following year, China's Ministry of Industry and Information Technology (MIIT) released a roadmap for AV development, which called for half of all vehicles to have driving assist or partially autonomous features by 2020, 10 to 20 percent of vehicles to be highly automated by 2025, and one in 10 vehicles to be fully autonomous by 2030.[353] That year, Changan, Ford's state-owned Chinese partner, tested a partially-autonomous vehicle on a 1,200-mile drive from Chongqing to Beijing.[354] In June 2017, a group of 98 automakers, universities, and institutes formed a strategic alliance to collaborate on research and standards.[355]

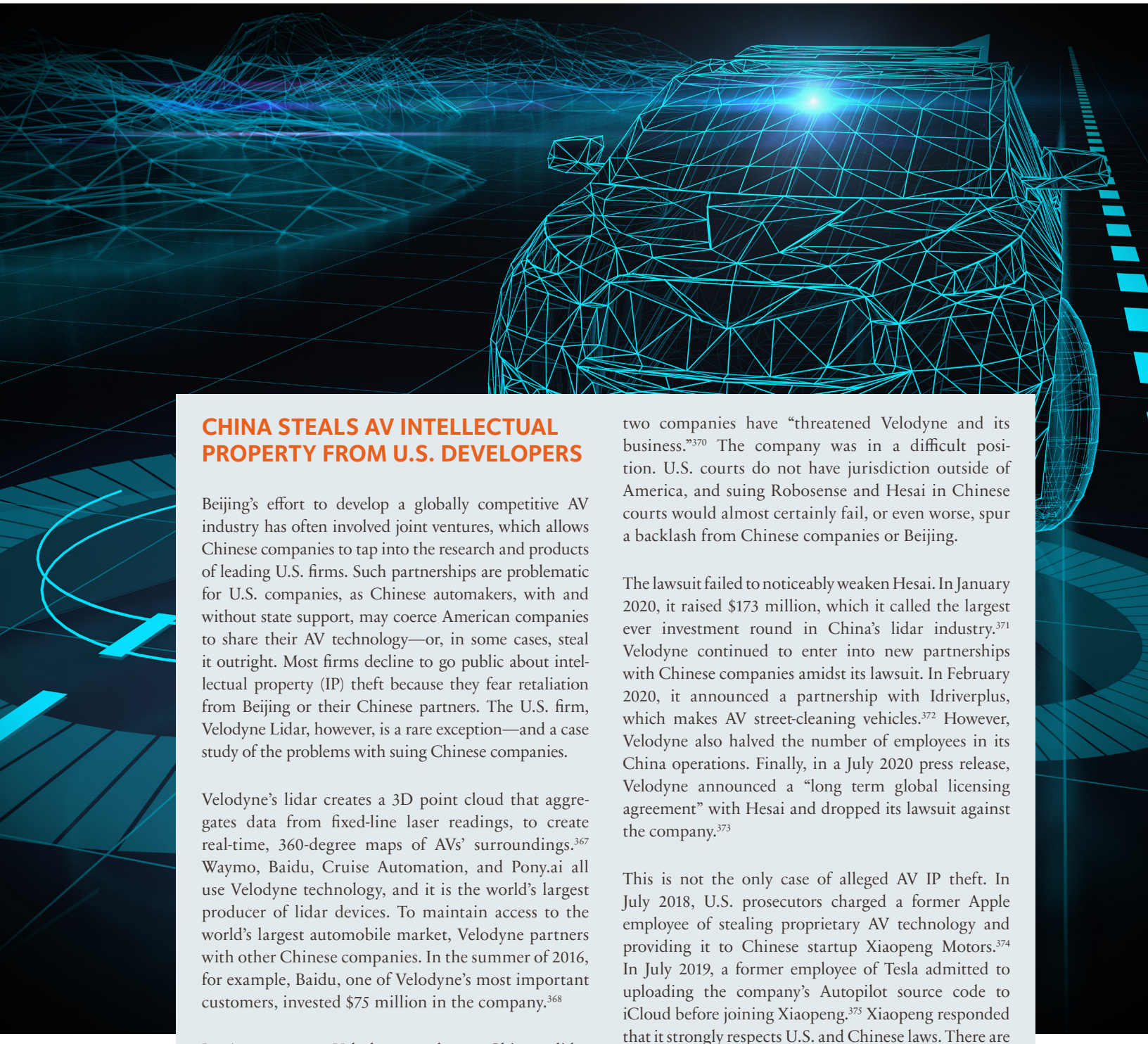
In 2018, China's National Development and Reform Commission (NDRC) unveiled a draft *Strategy for Innovation and Development of Smart Cars*, which created a framework for technology innovation, industrial and infrastructure development, and regulatory standards.[356] The strategy aims to establish a complete ecosystem for AVs in China, with nearly all new vehicles being "smart" vehicles by 2025; and to become a world leader in the AV industry and infrastructure by 2035.[357] Also in 2018, MIIT created AV road testing rules, setting the groundwork for testing in Shanghai, Guangzhou, Shenzhen, and Chongqing, so that Chinese AV companies would no longer have to test abroad.[358]

One of the biggest players in this space is Baidu, China's largest search engine, which in 2014 announced a highly autonomous car system program called the Apollo Project.[359] In September 2017, Baidu launched its $1.5 billion Apollo Fund to invest in 100 different AV-related projects from 2017 to 2020. This enabled Baidu to holistically collaborate with AV start-ups in the development of components for its AV system—vehicle, hardware, software, and cloud.[360] It is a rich space for entrepreneurs: eleven AV-oriented Chinese startups have received more than $100 million in funding, and another eleven have received more than $10 million.[361]

Besides working with local carmakers, Baidu has formed joint ventures with foreign companies. In 2018, it partnered with Ford to launch a two-year project to test AVs on Chinese roads, and, since 2014, it has worked with BMW on autonomous driving.[362] Baidu's fleet of 300 AVs clocked more than 1.2 million miles driving in 13 Chinese cities in 2019.[363]

Other Chinese tech titans have also entered the field. The digital giant Tencent partnered with BMW to build a computing center to support AVs, while Alibaba-backed AutoX, in a partnership with Fiat Chrysler, began testing AV taxis this year.[364] Start-ups Pony.ai and WeRide began piloting AV taxi services with human drivers onboard in 2019.[365] Rideshare giant DiDi Chuxing announced it will launch an AV pilot this year as well.[366]

350 National Conference of State Legislatures, "Autonomous Vehicles | Self-Driving Vehicles Enacted Legislation," Webpage, February 18, 2020.
351 Raphael Gindrat, "5G investment needs to scale up for AVs to reach full potential," Axios, December 12, 2018; and Russ Heaps, "Self-Driving Cars: What Is V2X Technology?" Autotrader, May 10, 2017.
352 SAIC Motors, "English Translation: SAIC and TTTech sign a joint venture contract to install a "smart brain" for driverless cars," available at: https://www.saicmotor.com/chinese/xwzx/xwk/2018/49922.shtml, March 13, 2018.
353 China Vehicle Engineering Institute, "Essentials of the Roadmap for New Energy and Smart Vehicle Technology," November 26, 2016.
354 See, e.g., Bloomberg News, "Self-Driving Car Completes 1,200-Mile Roadtrip Across China," Bloomberg, April 17, 2016.
355 See, e.g., Hao Yan, "Auto, tech specialists form alliance to guide future collaborations," China Daily, June 19, 2017.
356 Eurasia Group, "Chinese AV Ambitions at Risk Amid Trade War," July 9, 2019.
357 Ibid.
358 Ibid.
359 See, e.g., Baidu, "Autonomous Driving Unit," Webpage; and Apollo, "Smart Transportation Solution," Webpage.
360 See, e.g., Cate Cadell, "China's Baidu launches $1.5 billion autonomous driving fund," Reuters, September 21, 2017; and Scott Kennedy, *China's Risky Drive into New-Energy Vehicles*, Center for Strategic and International Studies, November 19, 2018, at page 40.
361 Crunchbase Query for "Autonomous Vehicle, China, Active," Webpage.
362 See, e.g., Rita Liao, "After Baidu tie-up, BMW taps Tencent for autonomous driving in China," Tech Crunch, July 19, 2019.
363 See, e.g., Kyle Wiggers, "Baidu's autonomous cars have driven more than 1 million miles across 13 cities in China," VentureBeat, July 2, 2019.
364 See, e.g., Norihiko Shirouzu, "BMW, Tencent to open computing center in China for self-driving cars," Reuters, July 18, 2019; and Breana Noble, "AutoX to launch robotaxi service with Chrysler Pacifica minivans," The Detroit News, January 8, 2020.
365 See, e.g., Christian Sheperd, "Pony.ai rolls out self-driving deliveries during lockdown," Financial Times, April 16, 2020; and WeRide, "About," Webpage.
366 See, e.g., Eva Xiao, "China's Didi Raises More Than $500 Million for Self-Driving Tech," The Wall Street Journal, March 29, 2020.



CHINA STEALS AV INTELLECTUAL PROPERTY FROM U.S. DEVELOPERS

Beijing's effort to develop a globally competitive AV industry has often involved joint ventures, which allows Chinese companies to tap into the research and products of leading U.S. firms. Such partnerships are problematic for U.S. companies, as Chinese automakers, with and without state support, may coerce American companies to share their AV technology—or, in some cases, steal it outright. Most firms decline to go public about intellectual property (IP) theft because they fear retaliation from Beijing or their Chinese partners. The U.S. firm, Velodyne Lidar, however, is a rare exception—and a case study of the problems with suing Chinese companies.

Velodyne's lidar creates a 3D point cloud that aggregates data from fixed-line laser readings, to create real-time, 360-degree maps of AVs' surroundings.[367] Waymo, Baidu, Cruise Automation, and Pony.ai all use Velodyne technology, and it is the world's largest producer of lidar devices. To maintain access to the world's largest automobile market, Velodyne partners with other Chinese companies. In the summer of 2016, for example, Baidu, one of Velodyne's most important customers, invested $75 million in the company.[368]

In August 2019, Velodyne sued two Chinese lidar companies, Robosense and Hesai, in U.S. federal court for intellectual property infringement.[369] Velodyne alleged that by copying its flagship technology, the two companies have "threatened Velodyne and its business."[370] The company was in a difficult position. U.S. courts do not have jurisdiction outside of America, and suing Robosense and Hesai in Chinese courts would almost certainly fail, or even worse, spur a backlash from Chinese companies or Beijing.

The lawsuit failed to noticeably weaken Hesai. In January 2020, it raised $173 million, which it called the largest ever investment round in China's lidar industry.[371] Velodyne continued to enter into new partnerships with Chinese companies amidst its lawsuit. In February 2020, it announced a partnership with Idriverplus, which makes AV street-cleaning vehicles.[372] However, Velodyne also halved the number of employees in its China operations. Finally, in a July 2020 press release, Velodyne announced a "long term global licensing agreement" with Hesai and dropped its lawsuit against the company.[373]

This is not the only case of alleged AV IP theft. In July 2018, U.S. prosecutors charged a former Apple employee of stealing proprietary AV technology and providing it to Chinese startup Xiaopeng Motors.[374] In July 2019, a former employee of Tesla admitted to uploading the company's Autopilot source code to iCloud before joining Xiaopeng.[375] Xiaopeng responded that it strongly respects U.S. and Chinese laws. There are almost certainly many more examples of AV IP theft—but the setbacks faced by companies like Velodyne deter companies from publicizing their experiences.

367 Echo Huang, "The world's leader in self-driving lidar technology is suing two Chinese companies over IP," Quartz, August 15, 2019.
368 See, e.g., Tycho De Feijter, "Why Did Baidu Invest $75M In Driverless Car Tech Firm Velodyne LiDAR?," Forbes, August 18, 2016.
369 Echo Huang, "The world's leader in self-driving lidar technology is suing two Chinese companies over IP," Quartz, August 15, 2019.
370 Ibid.
371 See, e.g., Yahoo Finance, "Hesai Raises $173M in Series C Led by Bosch and Lightspeed," January 9, 2020.
372 IHS Markit, "Chinese autonomous driving startup Idriverplus joins 'Automated by Velodyne' ecosystem," June 1, 2020.
373 See, e.g.,Velodyne Lidar, "Velodyne Lidar Inc. Announces Patent License Agreement with Hesai Photonics Technology," July 21, 2020.
374 See, e.g., Hannah Kuchler, "Apple worker charged with stealing self-driving car secrets," Financial Times, January 30, 2019.
375 See, e.g., Peter Blumberg, "Tesla Escalates Battle Over Alleged Theft of Robocar Secrets," Bloomberg, April 24, 2020.

Like with its EV industry, Beijing has used public policies and targeted investments to jumpstart its AV industry. However, unlike in the EV industry, China remains technologically behind the United States.[376] AV testing is crucial for data collection and improving system reliability.[377] Waymo cars have traveled more miles than all Chinese AV test cars combined.[378]

Beijing is striving to close the gap with the United States, with policies it hopes are realistic. Using its Government Guidance Fund, Beijing plans to spend $120 billion on AVs from 2018 to 2021.[379] The southern metropolis of Shenzhen, for example, has promised nearly $30 million to support the *Strategy for Innovation and Development of Smart Cars*.[380] The city will allocate funds to V2X communication technologies, radar, and lidar technologies.[381]

In January 2020 the NDRC, in collaboration with 10 other government agencies, revised and published its *Strategy for Innovation and Development of Smart Cars*. Analysts see the updated strategy as less ambitious than previous plans. It pushed back many AV production and deployment targets, like the widespread roll out of AVs with conditional self-driving capabilities, from 2020 to 2025.[382]

NRDC's new strategy continues to emphasize government-led AV development—unlike the United States, which has allowed a patchwork of regulations and legislation to develop. Beijing has implemented a clearer set of rules for road-testing, which may help the industry develop in a more standardized fashion, as well as help Chinese AV developers close the gap in technology development.

Beijing's approach may also enable China to take the lead in developing the infrastructure needed for widespread AV commercialization.[383] Beijing is undertaking a massive 5G 'Safe City' rollout, spearheaded by Huawei and Beijing.[384] Safe Cities provide services like social media monitoring, facial recognition, and other types of surveillance to cities around the world.[385] 5G will enable the development of V2X technologies, which could help facilitate the widespread deployment of AVs.[386] China's success in 5G deployment could be helpful in realizing its ambitions to become the dominant force in the AV industry. Beijing's quicker and more expansive rollout of 5G technology, along with its continued government support of the AV industry, could help China reach parity with the United States in the AV industry.

5G and Global Innovation

The telecommunication sector is undergoing a remarkable transformation. Fifth-generation (5G) wireless networks will not only deliver ultra-fast connectivity, but also increase reliability—filling in the holes of current cellular networks with profound interconnectedness. 5G promises internet connectivity 10- to 100-times faster than current fourth-generation (4G) wireless network speeds.[387] Advances in mobile broadband will enable greater levels of machine learning and cloud-based computing, which will significantly benefit the global economy.[388] 5G wireless telecommunication networks may also support the rollout of connected and AV technologies.[389]

The first wireless networks enabled the development of portable communications devices for voice calling, while 3G and 4G networks led to the creation of smartphones and the applications that now underpin major parts of the modern economy.[390] 5G's extensive capabilities will spur further innovation and novel applications. According to the World Economic Forum, the rollout of 5G networks could contribute more than $13 trillion to the world economy, and create more than 22 million jobs globally.[391]

376 See, e.g., Pete Bigelow, "China companies shift focus to commercializing AVs in effort to catch up to U.S.," Automotive News Europe, July 13, 2020.
377 James Drew, "Washington State in the Dark Over Public AV Testing," Government Technology, September 23, 2019.
378 See, e.g., The Economist, "Chinese firms are taking a different route to driverless cars," October 12, 2019.
379 Nikolaj Herskind, Chee-Kiang Lim, and Sophia Holst, "How China will shape the future of autonomous vehicles," Qvartz, May 2019.
380 China Auto News, "Up to 200 million yuan! Shenzhen Development and Reform Commission issued a notice to support the development of intelligent connected cars!," Sohu, May 29, 2020, available at: https://www.sohu.com/a/398576680_120044219.
381 Ibid.
382 Mark Schaub and Atticus Zhao, "China Releases Big Plan for Autonomous Vehicles," China Law Insight, March 4, 2020; and See, e.g., IHS Markit, "China delays mass production of conditional automated vehicles until 2025," February 25, 2020.
383 Eurasia Group, "Chinese AV Ambitions at Risk Amid Trade War," July 9, 2019, at page 1.
384 See, e.g., Bradley Jardine, "China's Surveillance State Has Eyes on Central Asia," Foreign Policy, November 15, 2019.
385 Jonathan E. Hillman and Maesea McCalpin, "Watching Huawei's 'Safe Cities,'" Center for Strategic and International Studies, November 4, 2019.
386 Eric Tanenblatt, "The Future of AV Hinges on More Than Tech," Connected World, November 1, 2019.
387 Aaron Pressman, "Here's how wireless carriers rank on 5G speeds, according to report," Fortune, February 20, 2020.
388 Miranda McClellan, Cristina Cervelló-Pastor, and Sebastià Sallent, "Deep Learning at the Mobile Edge: Opportunities for 5G Networks," Applied Sciences, July 9, 2020, at pages 1-2.
389 Raphael Gindrat, "5G investment needs to scale up for AVs to reach full potential," Axios, December 12, 2018.
390 Dan Littmann et al., "5G: The chance to lead for a decade," Deloitte, 2018, at page 3.
391 See, e.g., Hazem Galal and Derek O'Halloran, "The Impact of 5G: Creating New Value across Industries and Society," World Economic Forum, January 2020, at page 6.

In the United States, 5G networks could add $1.2 trillion to the economy, along with three million jobs, while in China, 5G technology could generate $1.5 trillion in economic value.[392] The countries that lead 5G deployment will likely capture a greater share of these benefits.

The widespread deployment of 5G networks will require significant investment in new cell sites, which will attach to a wide variety of city infrastructure like towers, street lamps, and building rooftops.[393] Unlike previous networks, which utilize geographically dispersed large cell towers, 5G requires many small cell sites to operationalize networks.[394] Greensill, one of the world's biggest non-bank providers of working capital, estimates the worldwide 5G rollout to top $2.7 trillion by the end of 2020 alone, with new small cell installations accounting for the most substantial capital investment cost.[395] Many industry experts believe 5G will facilitate the deployment of connected and autonomous vehicles: it provides "low latency," or the ability to exchange messages nearly instantaneously, which is critical for AVs that may rely on connectivity.[396]

The three most prominent connected vehicle technology platforms are vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P), collectively called V2X. V2X uses transponders installed in vehicles and key infrastructure to permit communication between elements of the transportation system, preventing crashes and allowing for more efficient traffic flow. V2X technology may allow AVs to communicate information about road conditions as they travel—expanding the vehicle's ability to anticipate objects beyond its line-of-sight, negotiate merges and stop signs, and increase efficiency by driving closer to other vehicles on the highway in "platoons."

392 Nicol Lee, *Navigating The U.S.-China 5G Competition*," The Brookings Institution, April 2020, at page 2; and See, e.g., Jane Zhang, "5G to stimulate US$500 billion in China tech growth over next five years, government researcher projects," South China Morning Post, August 1, 2019.
393 Nicol Lee, *Navigating The U.S.-China 5G Competition*," The Brookings Institution, April 2020, at page 2.
394 Ibid.
395 Greensill, "Financing the Future of 5G," Webpage, October 21, 2019.
396 James Sanders, "Why 5G is a crucial technology for autonomous vehicles," ZDNet, November 4, 2019.

City infrastructure that utilizes 5G technology could sync stoplights with real-time traffic patterns, optimizing cycles and reducing waiting time.[397]

The technology company Intel estimates that each AV deployed will generate around 4 terabytes of data every ninety minutes.[398] Without 5G, it may be more difficult to process and utilize that information.

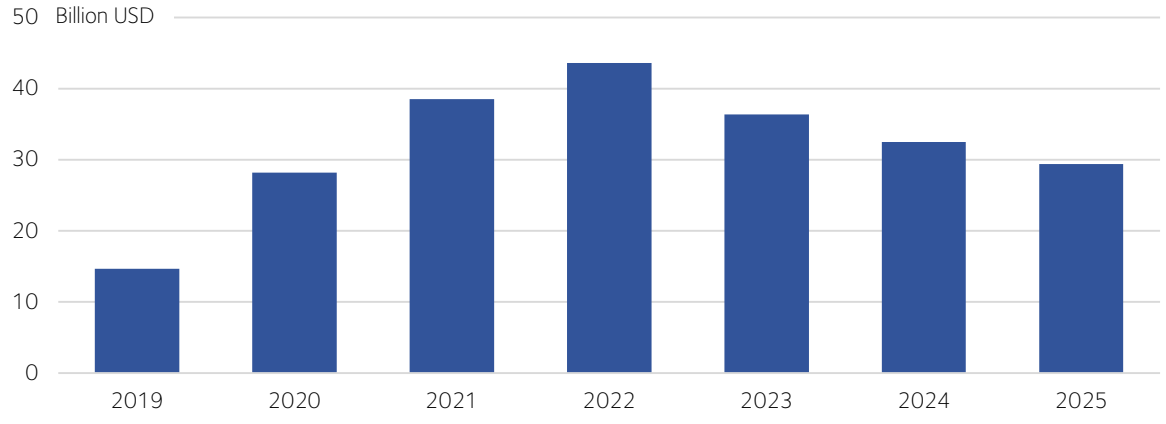
China's 5G Industry

China's government and telecommunications companies are aggressively pursuing 5G deployment and global leadership of that technology. In 2015, Beijing's *13th Five-Year Plan* identified 5G network development as a national priority.[399] From 2015 to 2018, China spent $24 billion more than the United States on 5G infrastructure, deploying more than 10 connected 5G sites for every site deployed in the United States.[400] By December 2019, China had built more than 60,000 5G base stations in 50 cities around the country.[401] Beijing has since accelerated its 5G infrastructure deployment, and by late 2020 China may have more than 500,000 base stations.[402] Goldman Sachs estimates that China will spend more than $150 billion on its 5G networks through 2025, while Ernst and Young forecasts that China will spend more than $220 billion over the same period.[403]

Through Huawei and ZTE, which control approximately 40 percent of the world's 5G infrastructure market, Beijing has become a major exporter of 5G technology.[404] Beijing has become an exporter largely because China is the largest market in the world, enabling the company to develop a global supply chain. Huawei now dominates the industry: by 2020, it claimed it had won more than 90 international contracts for its 5G software, low-cost equipment, and services.[405]

397 Mike Freeman, "The race for 5G and what you need to know," The Philadelphia Inquirer, August 28, 2019.
398 Kathy Winter, "For Self-Driving Cars, There's Big Meaning Behind One Big Number: 4 Terabytes," Intel, April 14, 2017.
399 Central Committee of the Communist Party of China, "The 13th Five-Year Plan for Economic and Social Development of the Peoples' Republic of China 2016-2020," 2015.
400 Dan Littmann et al., "5G: The chance to lead for a decade," Deloitte, 2018, at page 1.
401 See, e.g., Joseph Waring, "China Unicom looks to 5G to drive top-line growth," Mobile World Live, March 23, 2020.
402 See, e.g., River Davis, "U.S. Allies Capture China Tech Business Despite Washington's Curbs," The Wall Street Journal, June 29, 2020.
403 Goldman Sachs, "5G's Future in China," Conversation with Allen Chang, July 1, 2019; and Ernst and Young, "China is poised to win the 5G race," 2018.
404 See, e.g., Katie Benner, "China's Dominance of 5G Networks Puts U.S. Economic Future at Stake, Barr Warns," The New York Times, February 6, 2020.
405 Lauly Li and Cheng Ting-Fang, "Huawei claims over 90 contracts for 5G, leading Ericsson," Nikkei Asian Review, February 21, 2020.

FIGURE 15
5G Capital Expenditure Forecast in China, 2019 – 2025



Note: Converted to USD using exchange rate 6.77 RMB/USD.
Source: Ernst and Young

Nominally the largest private company in China, Huawei has benefitted greatly from its relationship with Beijing throughout most of its 33-year history. A Wall Street Journal investigation found that over the last 25 years, Huawei benefitted from up to $75 billion in state support.[406] Of that, roughly $46 billion came from credit lines, loans, and other support from state lenders; up to $25 billion in tax breaks and incentives; $2 billion in land discounts; and $1.6 billion in grants.[407] To put just one of those numbers in perspective, the official grants Huawei received between 2013 and 2018 were 17 times as large as the subsidies that Nokia, the world's second largest telecommunications equipment maker, received over the same period.[408] Ericsson AB, the world's third-largest maker, received no official grants during that period.[409] Huawei now owns 10 percent of essential 5G patents, and is the only player in the world able to supply all the technology required for a 5G build-out: base stations, antennas, handsets, and complex data center hardware and software.[410]

While Huawei's low-cost 5G equipment makes it an attractive choice for many countries, deploying its equipment poses significant national security threats.

Huawei, for example, helps export Beijing's "surveillance regime." In 2019, Huawei reached a $1 billion deal with Uzbekistan to build a traffic-monitoring system involving nearly 900 cameras.[411] The proliferation of such networks help Beijing access sensitive data globally.[412] In the United States, regulators have banned Huawei's technology from domestic use, citing intelligence community concerns that it is susceptible to cyberespionage.[413] The equipment is thought to have security flaws or backdoors, potentially providing Beijing with access to sensitive data and control over devices connected to its networks.[414]

Faced with the threat of Huawei technology in the American network, the United States has attempted to curtail Huawei's growth. In 2019, Congress passed the National Defense Authorization Act (NDAA), which included a provision banning federal agencies and their contractors from purchasing equipment or services from Huawei and ZTE.[415] The 2019 Secure and Trusted Communications Network Act (STCNA) also established a program to quickly replace existing Huawei and ZTE equipment from the U.S. network.[416] As of February 2020, Huawei's hardware comprised under one percent of all equipment used by U.S. telecom networks, mostly in rural

406 Chuin-Wei Yap, "State Support Helped Fuel Huawei's Global Rise," The Wall Street Journal, December 25, 2019.
407 Ibid.
408 Ibid.
409 Ibid.
410 Yuan Gao and Peter Elstrom, "Trump's Blacklisting of Huawei Is Failing to Halt Its Growth," Bloomberg, January 6, 2020; and Scott Kennedy, *China's Uneven High-Tech Drive*, Center for Strategic and International Studies, February 2020.
411 See, e.g., Bradley Jardine, "China's Surveillance State Has Eyes on Central Asia," Foreign Policy, November 15, 2019.
412 Ibid.
413 See, e.g., Ken Dilanian, "U.S. officials: Using Huawei tech opens door to Chinese spying, censorship," NBC News, May 22, 2019.
414 See e.g., Bojan Pancevski, "U.S. Officials Say Huawei Can Covertly Access Telecom Networks," The Wall Street Journal, February 12, 2020.
415 Sijia Jiang, "Huawei challenges U.S. defense bill as sanctions fight ramps up," Reuters, May 28, 2019; and Clare O'Gara, "Industry Group: Give Us More Time to Remove Chinese Tech," SecureWorld, April 7, 2020.
416 See, e.g., Katy Stech Ferek, "Senate OKs $1 Billion for Rural Telecom Carriers to Replace Huawei Gear," The Wall Street Journal, February 27, 2020.

areas.[417] The STCNA will provide up $1 billion to support small, rural network providers to replace prohibited equipment.[418] In May 2019, the U.S. Department of Commerce placed Huawei on its entity list, which implements restrictions on Huawei and its suppliers' ability to purchase technology, parts, or components from American companies without U.S. government approval.[419] Huawei's patents have also concerned U.S. federal prosecutors, who in January 2019 opened a criminal investigation into its alleged intellectual property theft.[420]

The United States worries that Chinese spyware will infiltrate the 5G networks of America and its allies. In February 2019, Secretary of State Mike Pompeo threatened to cut military and diplomatic ties with countries that purchase Huawei equipment, and warned that the United States would stop sharing intelligence with countries that use Huawei equipment in their 5G networks.[421] The United States has been only moderately successful in rallying its allies against Huawei: only Australia, Japan, Taiwan, and the United Kingdom have banned Huawei equipment. The European Union has stated that it would allow Huawei equipment into its network, and would increase its network security.[422] In the Netherlands, Huawei underbid the existing vendor Ericsson by more than 60 percent, underscoring the difficulty the United States faces in its fight against Huawei.[423]

The growing international influence of Huawei means that the United States risks ceding global leadership to a strategic adversary on crucial technology that will help shape the global economy, including the future transportation sector. If the United States wants to maintain its position as the global leader in innovation, as well as its lead in the AV industry, the United States should accelerate its 5G rollout.

Commercially driven investment decisions have slowed the 5G rollout in the United States. The U.S. 5G rollout may cost as much as $275 billion through 2024.[424] The U.S. government is offering limited support. In 2019, the Federal Communications Commission (FCC) launched the 5G FAST plan to help companies launch 5G infrastructure by delivering new spectrum assets and updating outdated regulations.[425] The FCC is also preparing to establish a fund of up to $9 billion to support the rural expansion of 5G networks, while the bipartisan Utilizing Strategic Allied (USA) Telecommunications Act would provide $1 billion to develop American alternatives to Chinese equipment.[426] Far more needs to be done.

The Role of Semiconductors

Semiconductors are the core of many major cutting-edge electronic products in the modern economy, and power innovation and development of technologies like 5G and AVs. Advances in semiconductors will enable higher volumes of data storage, faster data analysis and processing, and greater software efficiency. In AVs, semiconductors facilitate the functioning of components such as sensors and lidar, as well as sensor fusion—the processing of data from all the sensors in an AV.[427] A fully autonomous vehicle may require up to 3,500 semiconductors per unit.[428] In 5G, the radios that transmit signals and the devices that connect to the network both rely on semiconductors.[429] While the United States has been a global leader in innovation for decades, Beijing's ambitions to dominate the semiconductor industry threaten that status.

The U.S. semiconductor industry supports nearly 250,000 direct jobs, with semiconductor fabrication facilities (fabs) in 18 different states.[430] But while the United States remains a global leader in the design and research of chips, and in the manufacturing of some chip segments, nearly 80 percent of semiconductor fabs are in Asia, providing China an opportunity to leverage its regional influence.[431] Though many U.S. companies still conduct research and design domestically, the U.S. semiconductor industry has mostly outsourced its manufacturing to Asia, and U.S. companies rely on Asian producers for the most advanced chips.[432] It is a trend that worries both lawmakers—in June, Congress proposed an estimated $25 billion in tax credits and funding to strengthen domestic productions—and investors. When

417 Ibid.
418 U.S. Senate Committee on Commerce, Science, and Transportation, "President Signs Rip and Replace Bill Into Law," Press Release, March 12, 2020.
419 See, e.g., Ana Swanson, "U.S. Delivers Another Blow to Huawei With New Tech Restrictions," The New York Times, July 14, 2020.
420 Katie Benner, Paul Mozur and Raymond Zhong, "Huawei Said to Be Under U.S. Investigation in Trade-Secrets Case," The New York Times, January 16, 2019.
421 Alex Scroxton, "US may cut off countries that use Huawei in 5G networks," ComputerWeekly, February 22, 2019.
422 Scott Foster, "World splitting into pro and anti-Huawei camps," Asia Times, July 16, 2020; and Jon Porter, "EU supports Huawei use in 5G networks in defiance of US," The Verge, January 29, 2020..
423 Ellen Nakashima, "U.S. pushes hard for a ban on Huawei in Europe, but the firm's 5G prices are nearly irresistible," The Washington Post, May 29, 2019.
424 Doug Brake, "A U.S. National Strategy for 5G and Future Wireless Innovation," Information Technology and Innovation Foundation, April 27, 2020.
425 See, e.g., Federal Communications Commission, "The FCC's 5G FAST Plan," Webpage.
426 See, e.g., Office of Senator Mark Warner, "National Security Senators Introduce Bipartisan Legislation to Develop 5G Alternatives to Huawei," Press Release, January 14, 2020; and See, e.g., Bevin Fletcher, "FCC floats options for proposed $9B 5G rural fund," Fierce Wireless, April 1, 2020.
427 Elisabeth Cuneo, "Bosch introduces new semiconductor chip for improved navigation," Autonomous Vehicle Technology, June 9, 2020; and Timothy B. Lee, "How lidar makers are coping with slow progress of self-driving tech," Ars Technica, February 11, 2020; and Cristian Tangemann, "Sensor Fusion: Technical challenges for Level 4-5 self-driving vehicles," Automotive IQ, October 21, 2019.
428 David Coffin, Sarah Oliver, and John VerWey, *Building Vehicle Autonomy: Sensors, Semiconductors, Software and U.S. Competitiveness*, U.S. International Trade Commission, January 2020, at page 8.
429 Semiconductor Industry Association, "State of the U.S. Semiconductor Industry 2020," 2020, at page 11.
430 Ibid.
431 Semiconductor Industry Association, "State of the U.S. Semiconductor Industry 2020," 2020, at pages 12 and 16.
432 Ibid.

Intel, the world's largest chipmaker, announced in July that it too is considering outsourcing its manufacturing, its stock price tumbled 16 percent.[433]

China's semiconductor technology remains roughly two generations behind leading semiconductor companies in the United States, South Korea, and Taiwan. In 2019, only 16 percent of semiconductors used in China were produced in China.[434] Beijing aims to increase the share of domestically produced semiconductors in its market to 40 percent by 2020 and 70 percent by 2025.[435] To achieve this goal, Beijing has focused on the less complex segments of the semiconductor industry, such as memory chips, with an intention to move up the value chain: a similar pattern of development it has followed in other high-tech, innovative markets.[436] It plans to spend approximately $118 billion from 2020 to 2025: including $60 billion provided by provincial and municipal governments, and $47 billion raised by the China Integrated Circuit Industry Fund.[437] Various Chinese government bureaus have also announced the establishment a $150 billion fund to strengthen China's domestic semiconductor production. Funding will contribute to 19 new fabs.[438]

To realize its high-tech manufacturing ambitions, China must develop expertise in the research, design, and manufacture of semiconductors. In June 2014, Beijing published *Guidelines for Development and Promotion of The National Integrated Circuit Industry*.[439] That strategy discussed, in abstract terms, the potential to use joint ventures and acquisition of foreign innovations to access and transfer advanced semiconductor technology to its domestic companies.[440] By late 2017, Chinese companies had spent more than $11 billion acquiring more than 34 U.S. semiconductor companies.[441] While attempts to acquire prominent American chipmakers Micron Technology and Lattice, for example, have failed, Chinese companies have successfully bought out smaller U.S. chipmakers.[442]

The United States may not be able to deter China from investing in its domestic semiconductor industry, but the U.S. government has helped to slow its growth. The Committee on Foreign Investment in the United States (CFIUS), has intervened and terminated the Chinese acquisition of at least eight American companies since 2015, including Micron and Lattice.[443] In May 2020, the Trump administration utilized export controls to prevent companies from selling Huawei semiconductors produced with U.S. equipment.[444] The ban is designed to close a loophole from previous sanctions on the company, as many semiconductor facilities use American equipment.[445] The ban will make it more difficult for semiconductor producers to keep both the United States and China in its supply chains. The Trump administration hopes export controls will curtail the growth in China's high-tech industries and protect U.S. intellectual property.

Taiwan Semiconductor Manufacturing Co. (TSMC) is one of the manufacturers affected by the ban. One of the largest and most advanced semiconductor manufacturers in the world, TSMC supplies semiconductors to companies like Apple and Huawei, as well as to the U.S. military.[446] To continue supplying Huawei, TSMC now requires a permit from the U.S. Department of Commerce. Without the permit, TSMC may have to choose between the United States and China. TSMC recently announced that it would build a $12 billion fab in Arizona, creating nearly 1,600 jobs—but that will not resolve its permitting issue with Huawei.[447] Additional projects by other semiconductor giants could help the U.S. reestablish its domestic manufacturing base and ensure continued leadership in the industry.

433 See, e.g., Ian King, "Intel 'Stunning Failure' Heralds End of Era for U.S. Chip Sector," Bloomberg, July 24, 2020.
434 See, e.g., Josh Horwitz, Sijia Jiang, "China chip industry insiders voice caution on catch-up efforts," Reuters, June 13, 2019.
435 See, e.g., Arjun Kharpal, "China is ramping up its own chip industry amid a brewing tech war. That could hurt US firms," CNBC, June 4, 2019.
436 James Lewis, "Learning the Superior Techniques of the Barbarians," Center for Strategic and International Studies, January 2019.
437 Ibid.
438 Ibid.; and Bloomberg, "China Invites Foreign Cash to Build a World-Class Chip Industry," Industry Week, April 25, 2018; and David Keller, Jimmy Goodrich, and Zhi Su, "The U.S. Should be Concerned with its Declining Share of Chip Manufacturing, Not the Tiny Fraction of U.S. Chips Made in China," Semiconductor Industry Association Blog, July 10, 2020.
439 See, e.g., Christopher Thomas, "A new world under construction: China and semiconductors," McKinsey & Company, November 1, 2015.
440 John VerWey, "Chinese Semiconductor Industrial Policy: Past and Present," Journal of International Commerce and Economics, July 2019.
441 Ibid.
442 See, e.g., James Lewis, "Learning the Superior Techniques of the Barbarians," Center for Strategic and International Studies, January 2019.
443 See, e.g., The Wall Street Journal Editorial Board, "The Lattice Warning to China," The Wall Street Journal, September 15, 2017.
444 See, e.g., David Shepardson, Karen Freifeld, and Alexandra Alper, "U.S. moves to cut Huawei off from global chip suppliers as China eyes retaliation," Reuters, May 15, 2020.
445 See, e.g., Debby Wu, Yuan Gao, Philip Heijmans, and Ian King, "Huawei Employees See Dire Threat to Future from Latest Trump Salvo," Bloomberg, June 7, 2020.
446 Debby Wu and Ian King, "U.S.-China Fight Over Chip Kingpin Rattles Tech Industry," Bloomberg, May 17, 2020.
447 See, e.g., Debby Wu, "TSMC Scores Subsidies and Picks Site for $12 Billion U.S. Plant," Bloomberg, June 8, 2020.

Significance of Transportation Technologies to U.S. Economic and National Security

The overwhelming oil dependence of the U.S. transportation sector creates vulnerabilities with potentially drastic consequences for the U.S. economy and national security. Because of its own oil dependence, China experiences many of the same problems as the United States.

But Beijing has set strategic goals which may help it transition its transportation sector away from oil. If China succeeds, the United States could face the threats of Beijing's general economic dominance: its control of global supply chains, its ability to increasingly set global standards, and its potential to control aspects of the future of transportation via 5G—in addition to continued reliance on oil.

China's Strength in the Global Vehicle Market Weakens the U.S. Economy & Threatens Jobs

If China outcompetes the United States in future transportation technologies, fairly or unfairly, and becomes the global automotive innovation and manufacturing hub, this could irreparably harm the American auto industry and its workers. The most significant threat is to American jobs. In a worst-case scenario, it could cause the near collapse of the U.S. industry—erasing hundreds of thousands of direct jobs, and many of the nearly ten million indirect jobs dependent on vehicle manufacturing.[448]

The automotive industry remains a powerful driver of the American economy, accounting for roughly three percent of U.S. gross domestic product.[449] Over the next decade, the implementation of global fuel economy and emissions standards, consumer preferences for efficient and low-cost travel, and the growth of new mobility options such as ride-sharing and micromobility will change the auto industry. American automakers have realized that they must quickly adapt and have pledged to invest at least $39 billion in the EV industry over the next 10 years, with nearly 90 percent of that investment remaining in the United States.[450] This investment will facilitate scientific research, design and development, maintenance, infrastructure development, and sales and support.

Even if increasing U.S. levels of support keep pace with accelerating investments in China, the domestic auto industry remains at risk. To prevent China's dominance of automotive manufacturing, both industry and policymakers should focus on the opportunities that new transportation technologies offer. For example, U.S. workers may find jobs building EV infrastructure, supporting other parts of the vehicle supply chain, and mining for strategic minerals. The National Renewable Energy Laboratory found that the EV industry could create up to 109,000 new jobs annually through 2040, while Boston Consulting Group predicts that autonomous and electric vehicles will contribute 100,000 new jobs this decade, including 30,000 high-skilled positions.[451]

The development of AVs in the United States could also reshape the economy and create significant societal and economic benefits. Reduced congestion resulting from AV deployment creates a more productive economy by preventing Americans from wasting an estimated seven billion hours in traffic annually.[452] A study of traffic patterns and job locations found that AVs could improve access to large job markets for some economically depressed regions.[453] Development of 5G networks could create millions of new

448 See, e.g., Auto Alliance, "In Your State," Webpage.
449 See, e.g., Auto Alliance, "Economy," Webpage.
450 Paul Lienert and Christine Chan, "Electric Vehicles – Reuters Graphics," Reuters, April 4, 2019.
451 Boston Consulting Group, "Mobility and Automotive Industry to Create 100,000 Jobs, Exacerbating the Talent Shortage," Press Release, January 11, 2019; and National Renewable Energy Laboratory, National Economic Value Assessment of Plug-In Electric Vehicles, December 2016, at page xxv.
452 See, e.g., Erin Dooley, "Here's How Much Time Americans Waste in Traffic," ABC News, August 26, 2015.
453 See, e.g., Securing America's Future Energy, "America's Workforce and the Self-Driving Future," June 2018.

jobs, both through the deployment of infrastructure and the new applications that it may enable.

By pursuing rapid deployment of EVs, AVs, and 5G, for cars, buses, and trucks, the United States can enjoy the economic benefits of emerging transportation technologies while protecting the American automotive industry and its workers. The U.S. responses to the evolving transportation industry and a geopolitical landscape that increasingly involves Beijing will determine how much of the job creation and value will accrue to China, and how much will accrue to the United States.

Beijing's Long Game: Global Standards Setting

Beijing has increased its role in international standards-setting organizations for the emerging technologies it has prioritized, most notably for 5G.[454] Setting standards helps Beijing localize IP ownership, increase its prestige, improve its companies' competitiveness, and facilitate its understanding of the technology—while influencing standards bodies so they benefit China at the expense of others. The more influence Beijing has in global bodies—from major multinational organizations like the United Nations to obscure telecommunications bodies—the more it can influence global standards.

It is difficult to say if the fight against Huawei has weakened or strengthened China's influence over global 5G standards. To set standards, companies and experts must discuss the technical specifications of their technology to ensure that their equipment is interoperable. The Commerce Department's blacklisting of Huawei initially precluded American companies from sharing information and technology with Huawei, causing confusion as to whether U.S. companies could actively set standards. It was not until June 2020 that the Department of Commerce clarified that U.S. companies can collaborate with Huawei for standards-setting purposes.[455]

According to an October 2018 research report prepared for the bipartisan US-China Economic and Security Review Commission, Beijing employs a two-pronged strategy.[456] It wields its growing clout to increase its standard-shaping power in international standards bodies. At the same time, Beijing pushes—mostly through its partners on the Belt and Road Initiative—for countries to adopt its technology and standards.[457]

This strategy, which Beijing calls "Standardization Work," has enabled China to grow its influence in the standards setting space: by the end of 2018, Chinese companies had proposed more than 25 percent of 5G standards.[458] From 2011 to 2019, Chinese-led technical committees or subcommittees in the prominent global International Organization for Standardization (ISO) increased by 75 percent.[459] China is one of the leading contributors to the United Nation's International Telecommunications Union (ITU) budget; the organization's leader is China's Houlin Zhao.[460] Zhao has used his position to criticize U.S. concerns over Huawei's equipment.[461] In a March 2020 report, the consulting firm Strategy Analytics ranked Huawei first in terms of the influence it had over 5G standards at the 3rd Generation Partnership Project (3GPP), a crucial telecommunications standards body.[462]

Europe led the development of 3G standards, while the United States led the development of 4G standards and technologies.[463] Beijing's influence over the bodies that largely determine the technical specifications and protocols, which enable interoperability between companies and devices, provide Chinese companies an advantage as they design and develop 5G products and services.[464]

The United States and its allies may not feel immediate effects from Beijing's influence over standard-setting bodies, but the long-term danger is real. The United States must reengage its allies and redouble its efforts to reduce Beijing's influence over these organizations.

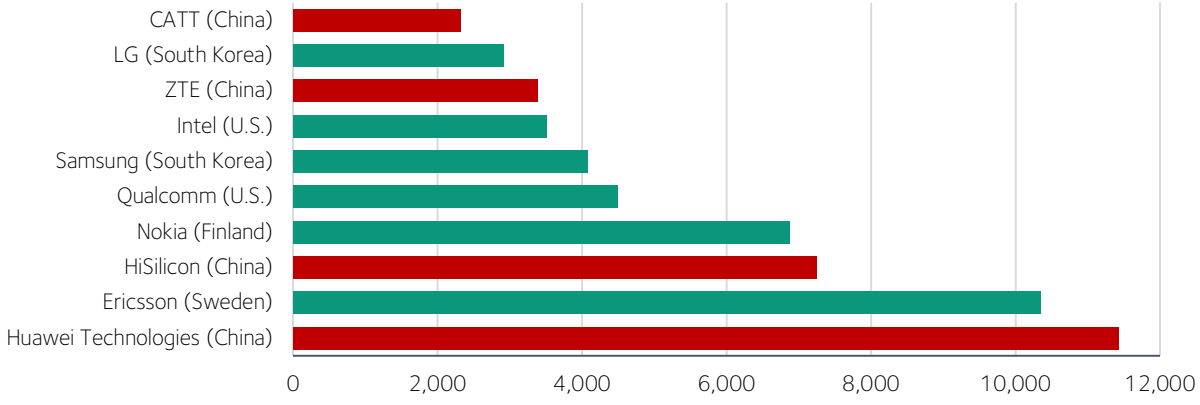
The 5G Threat

The most pressing issue for America is Beijing's potential control over the 5G industry via its national champion Huawei. This would not only economically benefit Beijing at America's expense, but also change the global narrative about the United States as the center of innovation—a shift with many negative implications for U.S. economic security. Huawei could utilize the massive amounts of unencrypted data flowing through its networks, or the metadata accessible on encrypted information, to gather valuable information

454 Hideaki Ryugen and Hiroyuki Akiyama, "China leads the way on global standards for 5G and beyond," Nikkei Asian Review, July 25, 2020.
455 See, e.g., Arjun Kharpal, "U.S. firms can work with Huawei on 5G and other standards. Here's what it means," CNBC, June 15, 2020.
456 John Chen, et al., "China's Internet of Things," Research Report Prepared on Behalf of the U.S.-China Economic and Security Review Commission, October 2018.
457 Ibid.
458 Dan Strumpf, "Where China Dominates in 5G Technology," The Wall Street Journal, February 26, 2019.
459 See, e.g., Jack Kamensky, "China's Participation in International Standards Setting: Benefits and Concerns for US Industry," China Business Review, February 7, 2020.
460 See, e.g., Theresa Hitchens, "US Risks Losing 5G Standard Setting Battle To China, Experts Say," Breaking Defense, May 11, 2020.
461 Tom Miles, "Huawei allegations driven by politics not evidence: U.N. telecoms chief," Reuters, April 5, 2019.
462 Strategy Analytics, "Strategy Analytics: Infrastructure Giants Lead 5G Standardization," Press Release, March 17, 2020.
463 See, e.g., Theresa Hitchens, "US Risks Losing 5G Standard Setting Battle To China, Experts Say," Breaking Defense, May 11, 2020.
464 See, e.g., Karen Freifeld and Chris Prentice, "U.S. drafts rule to allow Huawei and U.S. firms to work together on 5G standards," Reuters, May 6, 2020.

FIGURE 16

Number of 5G Standards Proposed as of December 2019, Select Companies



Source: Dan Strumpf, "Where China Dominates in 5G Technology," The Wall Street Journal, Feb 26, 2019.

about Americans.[465] Huawei could send false information, or not pass on true information, via base stations—the cell towers of 5G networks.[466]

Huawei dominating 5G would not only give Chinese companies a crucial tool to support their development of AV technology, but also weaken the guardrails which will keep AV technologies safe. Vehicle connectivity, supported by 5G, will integrate individual vehicles into the broader transportation system. Connected vehicle technologies allow for real-time traffic updates, collision avoidance, and more efficient routing and fuel use.[467] Passengers, corporations, investors, and regulators all must feel that these vehicles are safe and secure. Huawei lacks the reputation to provide the safety and security necessary for widespread implementation of 5G. Moreover, if Huawei dominates 5G, it could encourage U.S. AV leaders like Waymo to partner with the company, raising concerns that Huawei would access or steal their technology.

At its essence, Huawei's threat to U.S. national security boils down to a question of trust. In February 2019, Huawei's founder claimed that even if Chinese law required Huawei to aid in Chinese espionage efforts, it would not do so.[468] But in 2017, Beijing passed a National Security Law requiring any Chinese organization or citizen to "support, assist, and cooperate with state intelligence work in accordance with the law."[469] American legal scholars—while mindful that the Party sits above its own laws—saw this as a declaration that Beijing could coerce most Chinese companies to serve as proxies for its interests.[470] If tensions worsen and the United States and China enter a path to conflict or war, Huawei and its technology could serve as sleeper agents against the United States.

465 Julian E. Barnes, "White House Official Says Huawei Has Secret Back Door to Extract Data," The New York Times, February 11, 2020.
466 Yuan Yang, "What are the main security risks of using Huawei for 5G?" Financial Times, April 24, 2019.
467 U.S. Department of Transportation, "What Are the Benefits of Connected Vehicles?," Intelligent Transportation Systems Joint Program Office.
468 See, e.g., Lauren Feiner, "Huawei president promises not to spy on US as Trump considers banning the company's telecom equipment," CNBC, February 20, 2019.
469 See, e.g., Arjun Kharpal, "Huawei says it would never hand data to China's government. Experts say it wouldn't have a choice," CNBC, March 4, 2019.
470 Tom Simonite, "US Lawyers Don't Buy Huawei's Argument on Chinese Hacking," Wired, April 4, 2019.

Policy Recommendations

The United States has held a position of global leadership in the automotive sector for more than a century.

The industry has served as the foundation of the U.S. industrial base, generating substantial economic benefits that have fostered a vibrant U.S.-based technology ecosystem.[471] Yet today, the United States is at risk of losing its leadership position, and one of its most important strategic industries, to China. This could undermine the U.S. economy and threaten our national security. While Beijing has prioritized development of electric and autonomous transportation technologies, and the 5G networks on which they may ultimately rely, the United States has not. Such a predicament exists for several reasons.

1. **Failure to Recognize the Problem.** U.S. government policies support emerging transportation technologies, but not in a manner that acknowledges the seriousness of the strategic competition with China. Individual policies are often developed in response to discrete problems, but are not designed, aligned, or scaled as part of a comprehensive plan intended to respond to a strategic challenge. In contrast, Beijing sees the development of an advanced ground transportation-manufacturing sector and supply chain as a matter of national strategic importance, and has acted accordingly. Effectively, American companies are now competing against the Chinese Communist Party.

2. **Failure to Commit to Future Transportation Technologies.** While the world awaits the widespread deployment of connected and autonomous vehicle technologies of the future, it is starting to electrify the transportation system today: primarily to reduce carbon emissions in response to climate change, and to a lesser degree to enhance security by reducing oil dependence. China itself is prioritizing electrification in order to erode the advantages other countries hold in internal combustion engine technology. While Germany, France, Norway, the United Kingdom, and China are among the nations implementing policies that support near-term electrification, the United States has rolled back some of the regulations and policies designed to tackle those challenges.[472] The world is on the cusp of a global transformation in automotive technology, but the United States has not made the national commitment necessary to compete with China.

3. **Failure to Engage with Like-Minded Nations to Confront China.** The U.S. automotive industry's struggle against China for global leadership in future transportation technologies is part of a larger competition. Through its Belt and Road Initiative, its *Made in China 2025* industrial plan, its strategic deployment of foreign aid, and its participation in international institutions, Beijing seeks to surpass the United States in global power and influence.[473] The most effective solutions to managing China's ambitions are likely to be multilateral efforts with our economic and security partners. The United States must fully engage them in this effort, or risk allowing China to exert influence and power that might otherwise be constrained.

In response to these concerns, the U.S. government should recommit to supporting a robust, world-class automotive and truck manufacturing sector. To compete against Beijing's well-organized initiatives and sustained financial commitments, the U.S. government must demonstrate a significant commitment to an electrified and autonomous transportation future. First, the federal government must offer incentives and implement regulations to support the market for light-, medium-, and heavy-duty electric vehicles. Second, the government should provide grants, tax credits, and loan guarantees to support the manufacture of EVs, EV batteries, advanced vehicle components, and the manufacture and deployment of charging infrastructure. Third, as the manufacturing sector expands, companies should work to secure critical minerals supply chains and processing that are not reliant on China. The government should reform domestic mining regulations and work with our economic and security partners to secure access to foreign reserves.

Fourth, for the United States to lead the autonomous vehicle revolution, we must support the development and deployment of the technology needed to safely operate AVs with greater regulatory certainty. Fifth, a robust and secure 5G network is required to support mass deployment

471 Kim Hill, Adam Cooper, and Debra Menk, "Contribution of the Automotive Industry to the Economics of all Fifty States and the United States," Center for Automotive Research, April 2010.

472 IEA, *Global EV Outlook 2020*, June 2020.

473 Kira Goldring, "Here's why China could overtake the US as the next superpower – and why it might not," Business Insider, June 2, 2018.

of AVs. The government has recently taken important steps to enhance the security of the 5G network, but it still must address regulatory hurdles to the network's expansion. Sixth, the United States must work with our economic and security allies to ensure Chinese companies compete fairly in market-based economies, and to prevent the global deployment of Chinese equipment and infrastructure from undermining the security of the United States and its allies.

These six steps comprise a strategy to help the U.S. automotive and transportation industry compete for global leadership as the world transitions from internal combustion engines to an electric, autonomous, and connected vehicle future. This is a competition that the United States cannot afford to lose. But it will not win without meaningful and strategic commitments to its domestic auto- and truck-manufacturing sector.

The United States is at an inflection point. The pandemic has shown the risks of depending on China for goods critical to the U.S. economy. As the United States awakens to these risks, we must reassess our approach to doing business with China and adopt policies that will realign the relationship between our nations. The policy recommendations below are intended to accomplish these goals.

Policy Recommendations

Issue #1: Support the Advanced Fuel Vehicle Market and Domestic Manufacturing

The automotive industry is the backbone of U.S. industrial strength, responsible for employing or supporting nearly 10 million American workers in mostly well-paying jobs.[474] The industry represents approximately three percent of U.S. gross domestic product.[475] Its importance to the economy also reflects the depth of its supply chain: 75 percent of the value of its output pays for intermediate materials.[476] The automotive industry purchases inputs from a broad range of suppliers, including those in the metals, plastics, glass, and electronics sectors.[477] Because of its contribution to the national income, its support of millions of jobs, and its role in innovation, the auto sector plays an outsized role in the U.S. economy.

The primary factor behind China's growing strength in the automotive sector is its national strategic commitment to creating an EV market and supply chain.[478] To better compete with China, the United States must recommit to building its own EV market and supply chain. As demand for EVs grow, automakers will feel more secure in committing to EV manufacturing, encouraging additional battery manufacturers to produce closer to the market. If they produce more batteries, anodes, cathodes, and other components, manufacturers will likely invest additional capital in the market and commit critical R&D resources to the United States. And if more anodes, cathodes, and other components are manufactured domestically, their producers will feel more secure in entering into long-term agreements to secure the minerals from which those components are made. In other words, the private sector will make the vehicles that people want, but it cannot build more EVs than the market will absorb.

Although the first mass-produced EVs hit the market more than 10 years ago, they remain a niche product. Moreover, they are competing against an incumbent technology and ecosystem that has evolved over the past 100 years, with all of the advantages that incumbency provides. The U.S. government has long supported nascent industries when their success was aligned with the national interest.[479] The global transportation sector is on the cusp of revolutionary change, and Congress must support American manufacturers of all classes of vehicles. This would enable domestic manufacturers to retake the lead in the global competition to design and manufacture state-of-the-art vehicles that will define the future of transportation.

Proposal: Expand current federal incentives for advanced technology vehicles, and update fuel economy and emission regulations, to stimulate adoption.

Congress should reform the Light-Duty EV Tax Credit (30D) to ensure its benefits are accessible to more Americans, to encourage consumers to buy new EVs, and to establish a sunset date to spur the rapid expansion of EV manufacturing. This will enable the EV market in the United States to grow more quickly. More critically, however, 30D reform would signal to automakers and part suppliers that the United States is fully committed to EVs over the long term, which will strengthen the case for private sector investment across the entire supply chain. This program will enhance America's competitiveness with China in the EV supply chain, technology, and market.

474 Auto Alliance, "America's automobile industry is one of the most powerful engines driving the US economy."; and See also, U.S. Bureau of Labor Statistics, "Automotive Industry: Employment, Earnings, and Hours."; and Josh Bivens, "Updated employment multipliers for the U.S. economy," Economic Policy Institute, January 23, 2019.

475 Auto Alliance, "America's automobile industry is one of the most powerful engines driving the US economy."

476 Sungki Hong, Hannah G. Shell, and Qiuhan Sun, "How Important Are Production Networks to the U.S. Economy?," Federal Reserve Bank of St. Louis, January 8, 2019.

477 Ibid.

478 Evelyn Cheng, "Electric cars take the spotlight in China's post-coronavirus stimulus plans," CNBC, May 5, 2020.

479 National Research Council of the National Academies, "National Support for Emerging Industries," in *Rising to the Challenge: U.S. Innovation Policy for the Global Economy*, 2012, at page 321.

Further, as the government updates its greenhouse gas emission and fuel economy standards, it should focus more on EVs, including application of vehicle multipliers, which provide automakers extra credit for the sale of EVs. These updates would accelerate the growth of EV sales, making future aggressive reductions in emissions more feasible. Additionally, the emissions program should attribute carbon upstream emissions to the power generators that power electric vehicles—regulating the upstream emissions at the point of emission and not assigning them to the vehicle.

Recommendations

- Reform the Light-Duty EV Tax Credit (30D) to make it refundable so that it is more accessible to consumers, and encourage the expedited manufacturing and adoption of EVs in the passenger vehicle market.
    - Eliminate the volume limitation of 200,000 vehicles per manufacturer; initiate a gradual phase-down beginning on a date to be determined.
- Update fuel economy and greenhouse gas emission standards using a range of tools including, perhaps, vehicle multipliers, zero-emission vehicle requirements, or attribution of emissions to power plants. These tools could be used to shift the focus from obtaining decreasing marginal benefits of ever-tightening standards for internal combustion engines to accelerating the inevitable transition to EVs.

Proposal: Expand incentives for medium- and heavy-duty EVs.

Diversifying the fuels used in transportation advances U.S. energy security objectives, regardless of the size or shape of vehicle used. The potential for diversifying fuels in the freight and logistics sectors is particularly promising. Although class 3-8 vehicles comprise just 3.6 percent of vehicles on the road, they account for 27 percent of oil used in the U.S. transportation sector.[480] And as e-commerce grows in the coming decades, companies will expand their fleets to meet rising demand for deliveries.

The manufacture of larger EVs can be particularly helpful in supporting the battery industry. Larger and heavier vehicles require larger batteries, and growing demand for larger batteries can expand capacity to manufacture all types of batteries. Such growth will facilitate a domestic supply chain and reduce costs as the industry scales. Accordingly, the government should expand incentives for the purchase of EVs to include all classes of medium- and heavy-duty vehicles. Moreover, Congress can lower the cost of operating EVs by establishing a tax credit for the use of electricity to power vehicles to align its treatment with that of other alternative fuels.[481]

The United States also supports a burgeoning electric bus industry, which could further strengthen the nation's supply chain for batteries and other components essential to the construction of all EVs. Government policies have spurred the growth of this vital industry, supporting American jobs at advanced manufacturing facilities operated by companies like Proterra, Navistar, and Blue Bird.[482] Accelerating these fuel diversification efforts enables fleets to reduce their exposure to long-term oil price volatility and decreases the total cost of vehicle ownership, while also moving toward air quality attainment goals. Such policies will also expand and strengthen the foundation of the EV industry, allowing the United States to compete with China, which currently deploys 99 percent of the world's electric buses.[483]

State and local governments are also owners and operators of large fleets of vehicles. Providing additional federal support to states and local governments will reduce the upfront cost barriers to vehicle electrification. And it will help states and cities reduce the cost of ownership of their fleets, including electric buses, by reducing expenditures on fuel and maintenance.[484] Federal support would bolster the market for this important market segment, boost the local economy, and allow municipalities to enjoy the operational benefits of EVs.

The iconic U.S. Postal Service (USPS) delivery truck is long overdue for modernization and responsible replacement. The Grumman Long Life Vehicle (LLV) has delivered the nation's mail for more than two decades. However, it lacks many modern safety technologies, including anti-lock brakes, air conditioning, airbags, averages just 10 miles per gallon, and catches fire at concerning rates.[485] There have been more than 120 fires over the last five years.[486] In FY 2018, USPS spent $2

480 Stacy C. Davis and Robert G. Boundy, "Transportation Data Book Energy, Edition 38.1," Oak Ridge National Lab, Tables 1.14, 3.4, and 5.1, April, 2020.

481 26 U.S.C. § 6426.

482 Conner Smith, "Electric Trucks and Buses Overview," Atlas Public Policy, July 2019.

483 Katie Fehrenbacher, "China's electric bus leadership," GreenBiz, September 28, 2018.

484 See, e.g., Idaho National Laboratory, "Comparing Energy Costs per Mile for Electric and Gasoline-Fueled Vehicles."; and See, e.g., International Council on Clean Transportation, "Update on electric vehicle costs in the United States through 2030," April 2, 2019; and Nathaniel Bullard, "Electric Car Price Tag Shrinks Along With Battery Cost," Bloomberg Opinion, April 12, 2019; and California Air Resources Board, "Advanced Clean Trucks: Total Cost of Ownership Discussion Document," February 22, 2019; and Keith Kerman, "Reducing Maintenance Costs With Electric Vehicles," NYC Fleet Newsletter, March 8, 2019.

485 David Roberts, "A No-Brainer Stimulus Idea: Electrify USPS Mail Trucks," Vox, April 22, 2020.

486 Cyndia Zwahlen, "Safety Experts Alarmed by Mail Trucks Bursting into Flames," Trucks.com, May 13, 2019.

billion to maintain these vehicles.[487] Its fleet consumed 195 million gallons of gasoline and diesel in 2019.[488]

USPS is evaluating proposals from three teams to build its Next Generation Delivery Vehicle (NGDV), which may include EV and hybrid options.[489] To realize long-term cost savings, USPS should prioritize electrification. As USPS nears its $6 billion decision regarding the purchase of 180,000 vehicles that will last decades, both Congress and USPS should ensure that a majority of its vehicles are domestically-manufactured EVs.[490] This will provide another boost to building the supply chain in the United States, and support the necessary charging infrastructure.

Recommendations

- Establish a tax credit that covers up to 30 percent of the total cost, or a larger share of the incremental cost, of new domestically manufactured medium- and heavy-duty alternative fuel vehicles.
- Generously fund existing grant programs to subsidize the cost of electric transit buses, school buses, and port equipment (airports and seaports).
- Create a tax credit for the sale of electricity used to power vehicles, to align electricity's tax treatment with other alternative fuels.
- Enable the electrification of up to one-half of the USPS delivery fleet with a direct appropriation for vehicles and charging infrastructure.
- Expand funding for the Congestion Mitigation and Air Quality program, so state and local fleet managers can replace existing vehicles with electric, hybrid electric, or other advanced fuel vehicles.

Proposal: Support strategic investment in next-generation vehicle manufacturing and their supply chains.

The vehicle-manufacturing sector is an industry of critical importance to the U.S. economy. A globally competitive auto and truck industry, however, requires a type of manufacturing sophistication that lifts the entire economy. Because of the auto and truck sector's role in the economy, the government has a strong interest in the industry's sustained prosperity.

In 2007 and 2009, Congress created an Advanced Technology Vehicles Manufacturing (ATVM) incentive program, to be administered by the Department of Energy. The initiative was developed to support the manufacturing of highly efficient gasoline-powered and alternative fuel light-duty vehicles by constructing new factories and reconfiguring existing facilities.[491] In past years, the program has supported ambitious ventures in emerging technologies.[492] The program, as established by Congress, allowed for both loan guarantees[493] *and* grants.[494] While Congress funded the loan program, which has remaining loan authority, it never funded the grant program that was created for the exact same purposes.[495] Also in 2007, Congress established a Domestic Manufacturing Conversion Grant Program to encourage domestic production and sales of advanced fuel vehicles and their components with funding prioritized for the refurbishment or retooling of manufacturing facilities that have recently ceased operation or will cease operation in the near future.[496] This program also lacks funding.

Congress should generously fund the ATVM grant program and the Domestic Manufacturing Conversion grant program. Such funding would help companies across the entire advanced automotive supply chain retrofit existing auto manufacturing facilities for new technologies, and expand manufacturing capacity in the United States. Congress should also revisit the cap on ATVM grants, which is currently limited to 30 percent of the cost to reequip, expand, or establish a facility.[497] Elimination of the cap would ensure that the level of subsidy is sufficient to compete with the first mover advantage of Chinese manufacturing capacity, and to ensure that a boost in demand is accompanied by a boost in domestic supply, rather than by increased imports. Further, the eligibility criteria for the entire ATVM program (grants and loan guarantees) should be expanded to include medium- and heavy-duty AFVs, AVs, and all of their associated components. DOE should undertake an initiative to educate the community of parts and component suppliers, including those who manufacture batteries and their components, or motors and their components, about the program and how it might assist them.

487 Government Accountability Office, "U.S. Postal Service: Offering Nonpostal Services Through Its Delivery Network Would Likely Present Benefits and Limitations," Report GAO-20-190, December 18, 2019, at page 9.
488 U.S. Postal Service, "Fiscal Year 2019 Fleet Alternative Fuel Vehicle Program Report," February 15, 2020.
489 Jerry Hirsch, "Postal Service to Start Negotiations for Giant Mail Truck Contract," Trucks.com, August 11, 2020.
490 Ibid.
491 Office of the Chief Financial Officer, "Advanced Technology Vehicles Manufacturing Incentive Program," U.S. Department of Energy.
492 Note: In January 2017, DOE announced that the manufacturing of infrastructure for alternative vehicle fuels including electricity, hydrogen, liquefied natural gas, compressed natural gas, and biofuels may also be eligible under the ATVM program. U.S. Department of Energy, "Eighth Supplement to Loan Guarantee Solicitation Announcement," Loan Programs Office, January 9, 2017.
493 42 U.S.C. § 17013(d).
494 42 U.S.C. § 17013(c).
495 42 U.S.C. § 17013(c).
496 42 U.S.C. §16062.
497 28 U.S.C. § 48(c).

The ATVM Loan Program, administered by the Department of Energy, is a proven mechanism for supporting the expansion of domestic auto manufacturing. Government loan guarantee programs have been subject to criticism in other sectors as a result of bad actors. However, ATVM has produced positive results in supporting ambitious ventures in emerging technologies: 98 percent of the ATVM dollars loaned have been fully repaid—with interest.[498] ATVM loans have contributed to 17 facilities being built or retrofitted in eight states, leading to the direct employment of 38,000 Americans in automotive manufacturing.[499]

Despite these successes, and although the DOE still has more than $16.5 billion in loan authority and roughly $4 billion in credit subsidy appropriations available, it has not closed a new ATVM loan since 2011.[500] This could be because manufacturers have described the application process as having become particularly "burdensome" and "restrictive."[501] Moreover, fees associated with the application, including independent advisor fees and closing costs, further limit access to the program. Besides reducing these barriers, Congress should also expedite the timeline for review of applications.

To further incentivize immediate private-sector investment in domestic manufacturing, Congress should revive the 48C Advanced Manufacturing Tax Credit. This tax credit, originally established under the American Recovery and Reinvestment Act of 2009, provided a 30 percent tax credit to re-equip, expand, or establish domestic clean energy manufacturing facilities.[502] In reinstating this credit, Congress should expand product eligibility to include AV technologies and other emerging transportation technologies.

The government should also fund research and development (R&D) of new advanced vehicle technologies and next-generation, or solid state, batteries. R&D is a classic public good. Because private firms rarely capture all the benefits of their R&D, they chronically underfund it. To mitigate this underinvestment, the government should increase and sustain funding for R&D for advanced vehicle technologies, including batteries and their components—because of their central role in the vehicles of the future. As this industry evolves from a reliance on petroleum to electricity and other advanced technologies, innovation is key.

The transition from internal combustion engines to electric vehicles will also have an effect on the workers who have good paying jobs manufacturing vehicles and their components, including engines, transmissions, and exhaust systems. As manufacturing shifts to EVs, these workers' jobs are at risk. In awarding assistance to companies, the government should take into account the extent to which the companies commit to retrain workers and offer displaced workers the first opportunity at newly created jobs. The government should also support robust job training and assistance as workers transition to new jobs. This change will happen and jobs will be lost, so the United States can either chose to retrain workers or those jobs will likely be shipped overseas.

Pursuant to Executive Order No. 12,866, the Office of Management and Budget (OMB) reviews all significant federal regulations to ensure that they are cost effective, and that the agency is choosing the lowest cost approach to achieve its goals.[503] OMB also reviews regulations to examine their effects on small businesses and their paperwork burdens. The president should direct OMB to also review regulations to examine their effect on the competitiveness of the regulated industry.

Finally, the issues that affect vehicle manufacturing are addressed across cabinet agencies: no one office coordinates the full federal scope of policies that affect the industry. The president should designate an official at the White House to coordinate federal policies across agencies, to support the industry, and facilitate its transition and supply chain.

These investments in the automotive sector are a necessary component of a whole-of-government approach to responding to Beijing's commitment to emerging transportation technologies. The following recommendations offer a path to encourage the manufacture of the vehicles and their components in the United States.

Recommendations

- Generously fund the Advanced Technology Vehicles Manufacturing incentive program and the Domestic Manufacturing Conversion grant program through competitive grants to provide expeditious financial support to companies in building or retooling domestic manufacturing facilities for the entire advanced vehicle supply chain and their associated components, including batteries, cathodes, anodes,

498 Securing America's Future Energy, "Get America Moving Again (GAMA): Recommendations to Stimulate Renewal, Growth, and Global Leadership and Support National Security in the Movement of People and Goods," May 2020, at pages 12-13.

499 Blue Green Alliance, "Advanced Technology Vehicles Manufacturing Loans: Employment Impacts," November 1, 2016.

500 Ryan McCrimmon, "For GOP, Death of Manufacturing Loan Program Finally in Sight," Roll Call, May 16, 2018; and Bradley Berman, "Trump budget kills loan program sought by EV-maker Lordstown Motors," Electrek, February 12, 2020; and U.S. Government Accountability Office, "2020 Annual Report: Additional Opportunities to Reduce Fragmentation, Overlap, and Duplication and Achieve Billions in Financial Benefits," May 2020, at page 22.

501 Government Accountability Office, "Status of DOE Loan Programs: Briefing to Appropriations Committees," March 15, 2013.

502 U.S. Department of Energy, "Fact Sheet: 48C Manufacturing Tax Credits."

503 Federal Register, "Executive Order 12886 of September 30, 1993," Office of the Management and Budget, September 30, 1993.

and permanent magnets.

- Expand eligibility for assistance under ATVM to include manufacturing facilities for medium- and heavy-duty AFVs, AVs, and their associated components including batteries, anodes and cathodes.

- Update the ATVM loan program by:

  - Appropriating funds to reduce application costs, including the cost of independent financial advisors, and to accelerate the loan review process; and

  - Establishing a performance-based mechanism wherein manufacturers' repayment liability is decreased for each vehicle produced, effectively converting the program into a conditional grant program.

- Revive the 48C Advanced Manufacturing Tax Credit to provide a 30 percent investment tax credit to provide funding to re-equip, expand, or establish domestic manufacturing facilities in the clean energy and transportation technology sectors.

- Fund R&D to improve the energy density of batteries, new battery chemistries such as improved cathodes, and charging technology. Research is chronically underfunded and better or alternative chemistries can lower costs and reduce charging times.

- Take into account the extent to which the companies commit to retrain workers and offer displaced workers the first opportunity for newly created jobs in selecting grant recipients and fund robust job training and assistance as workers across the supply chain transition to new jobs.

- Direct OMB to review new significant regulations to determine if they reduce anticompetitive features to the greatest extent possible.

- Designate an official at the White House to coordinate federal policies affecting the vehicle manufacturing industry and national security.

Proposal: Invest in nationwide advanced fuel vehicle charging and refueling infrastructure.

The private sector has already begun to build out EV infrastructure, but a great deal of work remains. Significant federal investment in the nationwide EV infrastructure, which would incentivize private sector installation ahead of widespread adoption, would help establish a robust charging network throughout the country and contribute to near-term job creation. By diversifying its vehicle fleets, the United States can continue to enhance its energy, economic, and national security. The Edison Electric Institute estimates that the United States will need 900,000 public charging stations and 1.2 million Level 2 workplace-charging stations to support an estimated 18.7 million EVs by 2030.[504]

To spur immediate private-sector investment in the installation of vehicle charging infrastructure, Congress should convert the Alternative Fuel Vehicle Refueling Property Tax Credit (30C) into a refundable tax credit, eliminate the $30,000 limitation to account for the increased costs of DC Fast Chargers, and extend the tax credit through the end of 2025. It also should allow a larger credit for bidirectional chargers. These will have greater utility in the future as there is a growing interest and need in managing vehicle charging to complement the load curve on the electrical grid and provide ancillary services to grid operators. Legislation pending before Congress provides a framework for the U.S. Department of Transportation to issue grants that support the nationwide build-out of charging infrastructure for electric vehicles across the major national highway corridors.[505]

Congress should also create a competitive grant program for the construction of charging depots in major metropolitan areas. This will accelerate the electrification of transportation network companies (TNCs) and livery services, as well as the freight and logistics sector.

Recommendations

- Establish a grant program to fund the development of a nationwide network of electric vehicle charging infrastructure corridors throughout the United States.

- Update the Alternative Fuel Vehicle Refueling Property Tax Credit (30C):

  - Convert 30C to a refundable tax credit;

  - Eliminate the $30,000 limit per refueling property;

  - Increase the size of the credit for bidirectional charging infrastructure; and

  - Extend the credit through December 31, 2025.

504 Adam Cooper and Kellen Schefter, "Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030," Edison Electric Institute, November 2018.

505 See, e.g., America's Transportation Infrastructure Act of 2019 (S. 2302) Subtitle D, Sec. 1401. Passed by the Senate Environment and Public Works Committee on July 30, 2019; The Clean Corridors Act (S. 674, H.R. 2616).

- Create a competitive grant program to support the construction of charging depots equipped with DC Fast Chargers.

Issue #2: Develop a Critical Minerals Supply Chain That is Not Controlled by China

Modern society cannot progress without the minerals that are used to build the many products and devices that we all rely on. Stated simply, everything has to be made of something from somewhere—often from below the ground. For instance, the manufacture of EV batteries and permanent magnets for EV motors requires the use of several critical minerals and rare earth elements, many of which are found in the United States. As China has concentrated on growing its automotive sector in recent years, with an emphasis on EVs, it has undertaken a strategic effort to secure global mineral supply chains. China has already monopolized access to certain critical materials.[506] Rare earth elements, for instance, are widely available globally. However, China has a near monopoly on their processing.[507]

Parts of the seabed outside of any nation's exclusive economic zone contain substantial deposits of critical minerals, including nickel, manganese, copper, zinc, and cobalt. Pursuant to the United Nations Convention for the Law of the Sea, a treaty that the United States has signed, but not ratified, the International Seabed Authority (ISA) oversees all seabed mining in international waters. States that are members of the ISA may apply for exploration and exploitation contracts. Because the United States has not ratified the treaty, U.S. companies are not able to access this potentially valuable resource, even as other nations are actively exploring the seabed in preparation for mining.

To ensure that the United States has reliable access to all of the materials required to manufacture EVs and other new technologies, it must develop secure supply chains, including processing, that are not subject to Chinese control. Doing so will require allowing responsible mining in the United States for those minerals that exist domestically, investing in processing facilities, supporting R&D for recycling and the development of substitute materials, and working with allies to limit Beijing's ability to reduce U.S. access to foreign mineral reserves.

Proposal: Promote a U.S.-based supply chain for rare earth elements by chartering a cooperative to build and operate an integrated refining, processing, and metallurgical facility. Develop a thorium bank to manage the byproduct of the refining process.

Over the last several decades, China has made a concerted effort to dominate the rare earths global supply chain.[508] China benefits from its substantial deposits of rare earth minerals, its low cost of labor, and its lax environmental standards.[509] China both refines and processes rare earths through a group of state-directed companies, and it has leveraged its control to coerce foreign corporations to transfer technology in exchange for secure supply contracts.[510] China's control of rare earths presents a security risk to the United States and the other nations that require these elements to manufacture a wide range of defense and non-defense related products.

China has evolved from being just the leading resource producer of mined rare earths to also becoming the leading producer of separated rare earth oxides; it is now responsible for 95 percent of their global production.[511] Much of the discussion in the United States about rare earths has focused on the opening of rare earth mines in the United States. If, however, the United States does not establish the capacity to refine and process rare earth metals from oxides, and metallurgical facilities to produce metals and alloys, opening mines or creating refining and oxide separation capacity will only serve Beijing's interests. China will still control nearly all the capacity to produce the metals and alloys that are fabricated into components for a wide range of products, including EV motors. The United States has developed a strong chemical industry over the last several decades, which should provide an advantage as the United States looks to build a domestic supply chain.

U.S. and other non-Chinese companies have been unable to compete with China because no single company consumes enough rare earths to justify building its own refining and processing facilities—and companies cannot act together due to antitrust restrictions. The U.S. mining industry already disposes of enough rare earths in the tailings of other mined commodities to meet non-Chinese global demand. But potential domestic rare earth processors may be reluctant to accept tailings with heavy rare earths, because they usually contain increased concentrations of the mildly radioactive element

506 Bloomberg News, "U.S. Risks 'Devastating' Blow From China's Rare Earths Monopoly," Bloomberg, May 29, 2019.
507 Reuters, "U.S. dependence on China's rare earth: Trade war vulnerability," June 27, 2019.
508 Interview with Kristin Vekasi: China's Control of Rare Earth Metals," The National Bureau of Asian Research, August 13, 2019.
509 Marc Humphries, "Rare Earth Elements: The Global Supply Chain," Congressional Research Service, December 16, 2013, at pages 10-11; and Valerie Bailey Grasso, "Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress," Congressional Research Service, December 23, 2013, at page 1.
510 Ibid., at page 19; See also, "S. 2093: RE-Coop 21st Century Manufacturing Act," 116th Congress.
511 U.S. Department of Defense, "Annual Industrial Capabilities Report to Congress," Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy, October 2013, at page 25.

thorium.[512] This increases the cost of processing rare earths in the United States due to regulatory licensing, compliance and disposal costs as required by the Nuclear Regulatory Commission.[513] Thorium has some industrial uses and might someday serve as a fuel source in a new nuclear fuel cycle—a prospect China is working to develop.[514]

A U.S.-based cooperative to refine rare earths could compete with Chinese suppliers by pooling public and private capital to build and operate an integrated refining, processing and metallurgical facility. By locking in cooperative members—from across the United States and our economic and security partners—as buyers for the rare earth products, the cooperative could guarantee a steady stream of revenue while also locking in an uninterruptible supply of rare earth metals and materials. Members would receive access to products in exchange for committing to purchase specified volumes at the cooperative's cost, which should remain reasonable because the cooperative's customers are also its owners. Though prices might be higher than prices offered by the Chinese, the supply chain would be secure, and the prices stable—and not manipulated by Chinese companies.

Recommendations

- Grant interested companies from the United States—and our economic and security partners—a federal charter for a cooperative to refine and process rare earth elements in the United States, and provide it an antitrust safe harbor so that the companies may work together to form the cooperative.

- Grant a federal charter to an entity to take ownership of, and accept liability for, the mildly radioactive element, thorium, produced as a byproduct of rare earth refining, store it consistent with all regulatory requirements, and expand the market for thorium.

- Fund research to develop industrial, defense, and energy applications for thorium.

Proposal: Support a domestic supply chain for critical minerals.

Apart from rare earths elements, there are several additional minerals critical to EV manufacturing, including nickel, cobalt, lithium, and graphite. While the United States has some reserves of nickel, lithium, and graphite, developing new domestic resources is difficult because of the cost and the time required to permit new mines. Failure to update our permitting processes has led to increased reliance on foreign minerals.

It is important that new mines undergo a thorough environmental review and operate in an environmentally responsible manner, complying with all federal and state environmental requirements. However, the permitting process averages between seven and ten years for new projects in the United States.[515] Delayed permitting undermines the economics of domestic mineral production by reducing the value of new mines. In fact, the United States' share of global investment in mining has fallen by half over the past two decades.[516] It takes roughly two years in Canada and Australia, two nations with strong environmental guidelines similar to the National Environmental Policy Act, the law that governs the review process in the United States.[517] This is reflected in the disparity in mining investment, with Canada and Australia each attracting approximately three times as much investment as the United States in recent years.[518]

Mandated timelines present a challenge because it is difficult to assign a single timeline to the wide range of mining projects that companies seek to pursue. Ecosystems vary across the country and the complexity of each project is unique. Nevertheless, the government must improve interagency and intergovernmental coordination and accountability. In early 2020, the government took an important step in this direction by extending access to the Federal Permitting Improvement Steering Council to the non-energy mining sector.[519] The Council, whose authorization extends until December 2022, is intended to improve transparency, predictability, and accountability throughout the permitting process.[520]

It is equally important that our nation reach a new consensus amongst government at the federal and state levels, and stakeholder groups, to facilitate mining. Even if the permitting process works well, mines can be delayed by endless litigation that Congress and the Executive Branch cannot easily avoid by legislation or regulation. To help reach a new consensus the federal government should convene an advisory group or commission to develop an

512 David An, "Critical Rare Earths, National Security, and U.S.-China Interactions: A Portfolio Approach to Dysprosium Policy Design," Pardee RAND Graduate School, 2015.
513 U.S. Nuclear Regulatory Commission, "§ 171.16 Annual fees: Materials licensees, holders of certificates of compliance, holders of sealed source and device registrations, holders of quality assurance program approvals, and government agencies licensed by the NRC," August 21, 2020.
514 World Nuclear Association, "Thorium," February 2017.
515 SNL Metals & Mining, *Permitting, Economic Value and Mining in the United States*, June 19, 2015, at page 7.
516 SNL Metals & Mining, "U.S. Mines to Market," September 9, 2014.
517 SNL Metals & Mining, *Permitting, Economic Value and Mining in the United States*, June 19, 2015, at page 7.
518 S&P Global Market Intelligence, "PDAC Special Edition: World Exploration Trends 2018," March 2019, at pages 3 and 8.
519 Federal Permitting Improvement Steering Council, "Federal Permitting Improvement Steering Council adds New Mining Sector," (Jan. 15, 2020).
520 Congressional Budget Office Cost Estimate, "S. 1976, Federal Permitting Reform and Jobs Act," (Oct. 11, 2019).

updated approach to mining. In developing that approach, the group should consider:

- the importance of mining to ensuring a secure supply chains for manufactured goods;
- the need to adhere to strict environmental standards;
- an understanding that necessary projects should not be delayed interminably, which undermines their economic viability;
- the need to fund research for advanced materials with a superior environmental footprint; and
- the obligation to recycle when possible to ensure that we do not mine unnecessarily.

The United States should not presume continued reliance on minerals for which it cannot develop secure supply chains. Battery chemistries have evolved over time and will continue to do so, possibly with the introduction of solid-state batteries. The government should fund R&D of new battery chemistries that can increase energy density and lower costs. Likewise, the government should increase funding for research and development into recycling of critical minerals, financially support recycling where it exists, and fund pilot projects, with the goal of increasing the share of recycled inputs into new products and decreasing our reliance on virgin materials over time.

Finally, public data about the size of U.S. reserves, production, recycling, and cost is insufficient to inform policymakers and stakeholders about the issues facing this industry. Congress should mandate the collection of such industry data and publish regular reports.

Recommendations

- ➤ Permanently authorize the Federal Permitting Improvement Steering Council, which provides transparency on the process of permitting large infrastructure projects.
- ➤ Prior to the end of 2022, the government should examine whether the mining sector's participation in the Council has improved mine permitting.
- ➤ Convene an advisory group representing all relevant governments and stakeholders to shape an updated approach to mining consistent with the following principles:
  - Accelerate the mine permitting process while ensuring that all mines meet strict environmental standards;
  - Modernize our nation's mineral permitting system by implementing best practices that reduce duplication and unnecessary delays, like requiring coordination among agencies;
  - Fund R&D regarding the efficient production, use, and recycling of critical minerals throughout the supply chain and support mineral recycling though grants or tax incentives; and
  - Explore tax incentives such as higher depletion allowance or limits on use of depletion allowances for production of critical minerals.
- ➤ Collect data and publish regular reporting of key quantitative metrics in the mining industry, similar to what the U.S. Department of Energy does with its Energy Information Administration (EIA).
- ➤ Support R&D, grants, and tax incentives to support recycling and development of new materials, including a tax credit to offset the incremental cost of recycled lithium above the cost of virgin lithium.
- ➤ Require that battery manufacturers place a code on batteries that can be used to identify the mineral components of the battery to facilitate recycling.

Proposal: Diversify mineral supplies for which there are not reserves in the United States.

There are several critical minerals for which there are either no or limited domestic reserves. China has substantial graphite reserves, for example, with some East African nations and Madagascar also boasting significant reserves.[521] Cobalt is produced primarily in the Democratic Republic of the Congo, though China has secured access by contract to more than half of the cobalt mines in the DRC.[522] Moreover, it is widely reported that child labor is used in the DRC mines.[523] Lithium is produced primarily in Australia, Chile, Argentina, and China, though the United States, Bolivia, Austria, and Russia have substantial reserves. Notable nickel producers include Indonesia, the Philippines, Russia, and Australia, though the United States also holds some reserves.

521 Priscila Barrera, "9 Top Graphite-Mining Countries," Graphite Investing News, August 14, 2019
522 Jack Farchy and Hayley Warren, "China Has a Secret Weapon in the Race to Dominate Electric Cars," Bloomberg, December 2, 2018.
523 U.S. Department of Labor, "2018 Finding on the Worst Forms of Child Labor: Congo, Democratic Republic of the," Bureau of International Labor Affairs, 2018.

American companies have less aggressively secured minerals for battery and vehicle manufacturing because the size of the U.S. market is smaller than the Chinese market, and because of tepid government support for EVs, and EV and battery manufacturers in the United States.[524] If the U.S. government makes a long-term and stable commitment to EVs—and the automakers are confident in the strength of that commitment—it will incentivize them to direct more of their global investment in EVs to the United States. Those investments will reverberate up the supply chain, providing component manufacturers the confidence to enter into agreements with foreign mineral producers to secure access to their materials.

Some of the critical mineral reserves are located in countries with which we have close economic and security ties. The government should share its concerns about mineral access with those nations, whose interests are often aligned with the United States. Moreover, the United States should work with allies to implement requirements that oversee and limit foreign direct investments, similar to the regulations enforced by the Committee on Foreign Investment in the United States (CFIUS), or significant supply contracts through which a foreign company might secure exclusive access to critical minerals. Finally, the government should invest in R&D for substitutes for critical materials that are difficult to source abroad.

Recommendations

- Work with allied nations to encourage them to limit Chinese investment in critical resource reserves.
- Commit to long-term R&D funding for the purpose of developing substitute materials for any critical minerals that are expected to face supply shortages.
- The United States should ratify the United Nations Convention for the Law of the Sea and join the International Seabed Authority so that American companies can explore and eventually access valuable mineral resources on the seabed.

Issue #3: Advance Next-Generation Transportation Technologies

The United States is on the cusp of a transportation revolution. EVs will reduce fuel consumption and emissions, addressing two critical national challenges. Autonomous and connected vehicles will increase safety and potentially save thousands of lives each year by reducing accidents, enhance mobility for individuals and households with inadequate access to transportation, force a rethinking of transportation business models while increasing productivity, and allow for driverless delivery of goods in a post-COVID world. Moreover, because these next-generation transportation technologies are likely to be electric, deployment can accelerate the adoption of EVs, with their attendant environmental, economic, and security benefits.

5G is the latest iteration of enhanced mobile broadband, which delivers internet speeds that are 10- to 100-times faster than current technology.[525] It may prove to be a critical part of AV infrastructure upon widespread adoption, allowing vehicles to communicate with other vehicles and transportation infrastructure.[526] Integrating 5G into the transportation system will be transformative for Americans—generating billions of dollars in economic benefits, reducing congestion, and saving lives.

But China is far ahead in 5G deployment: it has roughly ten times as many 5G connected sites than the United States.[527] Moreover, the growing international influence of its state-supported telecommunications giant Huawei means the United States risks ceding to China the global leadership on crucial technology that will shape the global economy. Embedding Huawei equipment in the infrastructure of the United States and its security partners will create security and privacy risks. The United States must accelerate 5G deployment, maintain engagement in international standard setting bodies, and work to reduce the use of risky infrastructure in our security partners' networks, as well as our own.

Proposal: Modernize motor vehicle regulations in order to preserve and strengthen American leadership in AV technology.

While the United States is a global leader in AV development, the nation risks falling behind if the federal government fails to modernize outdated regulations that act as barriers to AV testing and deployment. In its 2019 Autonomous Vehicle Readiness Index, KPMG ranked the United States third in technology and innovation for AVs—but ninth in policy and regulation.[528]

Many of the nation's automotive regulations, known as Federal Motor Vehicle Safety Standards (FMVSS), were written before AVs were considered possible. These

524 Umair Irfan, "Why US Carmakers are Betting on Electric Vehicles and SUVs at the Same Time," Vox, December 4, 2018.

525 Bob O'Donnell, "How Fast Will 5G Really Be?" Forbes, November 19, 2019.

526 Stephen Shankland, "5G could make self-driving cars smarter and commutes safer," CNET, August 27, 2019.

527 Stu Woo, "In the Race to Dominate 5G, China Sprints Ahead," The Wall Street Journal, September 7, 2019.

528 KPMG, 2019 Autonomous Vehicles Readiness Index, KPMG, February 17, 2019.

standards often assume that a human driver will operate a vehicle, and frequently reference the location of the driver's seat as a means of certifying safety compliance. This causes numerous unforeseen and unintended obstacles to AV deployment. For example, some FMVSS require every motor vehicle to be equipped with manual controls (e.g., steering wheels and brake pedals).[529] These standards may be impossible to meet for vehicles that will not have human drivers, and especially those that will not even carry human occupants. By reforming these regulations we will also allow manufacturers to focus on form factors that improve the efficiency of the vehicles.

The National Highway Traffic Safety Administration (NHTSA) has started the process of revising its standards in order to reduce unintended barriers to AVs, while preserving the original safety intent of each standard.[530] Yet promulgating new standards is a complex process that takes years to complete—a far slower rate than AV technology is developing. Beijing can simply adjust its regulations by fiat.

Fortunately, AV manufacturers may pursue a temporary pathway for deployment of AVs with unconventional designs by petitioning NHTSA for exemptions from specific FMVSS.[531] This well-established pathway could be critical to the development of new safety and alternative fuel technologies, and is vital to the advancement of autonomous vehicles—a global industry into which U.S. automakers and technology developers have already invested billions of dollars.[532]

However, companies are limited to exemptions for up to 2,500 vehicles, an insufficient volume to allow for scale production of these transformative vehicles, which limits the innovation of form factors and designs which can improve efficiency or accelerate electrification.[533] The U.S. Department of Transportation noted that the current exemption structure must be updated to allow for U.S. companies to compete globally.[534] U.S. competitors—most notably China—face no such barriers, and companies in China have rushed to seize this competitive advantage, particularly as most AV testing fleets in the United States remain "grounded" due to state and local closure requirements related to the pandemic.[535]

In advance of comprehensive AV regulatory reform, Congress could provide a near-term path to continued investment, domestic job creation, and U.S. global leadership, through reform that does not add to the deficit. First, Congress should preserve the role of the federal government (via the National Highway Traffic Safety Administration) as the sole regulator of design, construction, and performance of motor vehicles, to avoid a patchwork of state safety standards. Secondly, Congress should support National Highway Traffic Safety Administration's (NHTSA) efforts to modernize FMVSS and establish reasonable, yet expeditious, timelines for progress. Finally, Congress should authorize NHTSA to grant exemptions for up to 100,000 vehicles per manufacturer, to provide an interim pathway for the deployment of AVs with novel designs as long as they are as safe or safer than current designs.

Recommendations

- Federal regulation of automotive safety should evolve to a more flexible and collaborative model predicated on performance-based standards, by adopting industry consensus standards within 18 months of their completion.

- Enable the domestic, at-scale manufacturing of AVs by providing NHTSA with the authority to grant Federal Motor Vehicle Safety Standards (FMVSS) exemptions for up to 100,000 vehicles per manufacturer—as long as the manufacturer demonstrates to NHTSA that the vehicle is as safe as, or safer than, FMVSS-compliant vehicles.

Proposal: Preserve the 5.9 GHz spectrum band (the "Safety Band") for the exclusive use of connected vehicle technologies.

Vehicle-to-everything (V2X) communications technology holds tremendous promise to meaningfully reduce oil consumption in the U.S. transportation system and significantly enhance traffic safety, which costs lives and billions of dollars per year. Through a variety of features including collision avoidance and red-light warnings, V2X has the potential to make a significant impact in reducing collisions—particularly those involving vehicles that are not in each other's direct line of sight. The U.S. Department of Transportation (USDOT) found that V2X can reduce the number and severity of collisions involving unimpaired

529 Greg Rogers, "A Primer on Federal Motor Vehicle Safety Standards and AVs," Eno Center for Transportation, October 26, 2017.
530 National Highway Traffic Safety Administration, "NHTSA Issues First-Ever Proposal to Modernize Occupant Protection Safety Standards for Vehicles Without Manual Controls," Press Release, March 17, 2020.
531 Greg Rogers, "A Primer on Federal Motor Vehicle Safety Standards and AVs," Eno Center for Transportation, October 26, 2017.
532 Jennifer Leigh Parker, "Driverless Cars Gain Speed, Despite Global Shutdown," CNBC, August 7, 2020.
533 National Highway Traffic Safety Administration, *Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety*, U.S. Department of Transportation, September 2016.
534 U.S. Department of Transportation, "Testimony of Dr. James C. Owens, Acting Administrator National Highway Traffic Safety Administration Before the Committee on Commerce, Science & Transportation United States Senate Highly Automated Vehicles: Federal Perspectives on the Deployment of Safety Technology," November 20, 2019
535 Emily Wong, "Baidu sets up self-driving test ground in China's Chongqing," Tech Wire Asia, March 24, 2020; and Kyle Wiggers, "Despite setbacks, coronavirus could hasten the adoption of autonomous vehicles and delivery robots," VentureBeat, March 20, 2020.

drivers by roughly 80 percent.[536]

Connectivity is a complementary technology for advanced driver-assistance systems and autonomous vehicles. SAFE's research shows that if these available safety technologies are widely deployed alongside other traditional efficiency technologies, the combination could lead to system-wide fuel savings of 18 to 25 percent and save 9,900 lives per year.[537] Consumer Reports recently estimated that these technologies could save more than 16,000 lives annually.[538]

Twenty years ago, the United States positioned its transportation network to remain globally competitive by dedicating 75 MHz to transportation applications. The Federal Communications Commission (FCC) has recently argued that the United States' allocation of the 5.9 GHz spectrum for transportation applications is larger than other countries, and it should therefore reduce it to align with international norms. However, the 75 MHz allocated by the United States is equal to those of Mexico and Canada, allowing drivers crossing these borders to receive the same safety and efficiency benefits across North America. Other countries have similar allocations, including South Korea (70 MHz), Australia (70 MHz), and Singapore (50 MHz).[539] Furthermore, the European Union allocates 30 MHz for transportation safety communications, with a pending proposal from its Electronic Communications Committee for expanding to 50 MHz for transportation safety, and an additional 20 MHz for non-safety applications.[540]

The FCC should consider the value of preserving the full 75 MHz band for transportation applications. By leveraging connectivity to achieve reductions in collisions, congestion, and oil consumption, it will ensure that the U.S. transportation sector—the key driver of the nation's economy—remains globally competitive. While some stakeholders have suggested that a portion of the spectrum may be shared with certain non-transportation uses, a 2019 Department of Transportation study of interference between devices sharing spectrum concluded that "[w]hile additional testing is needed to determine the level of interference from one device to another, it is clear that interference will occur, raising the question of the reliability of V2X communications in this configuration."[541]

Recommendations

- The FCC, in coordination with NHTSA and other federal agencies, must provide the necessary regulatory clarity and policy consistency to enable the widespread deployment of V2X.
- The FCC should preserve the full 75 MHz of spectrum in the 5.9 GHz band for Intelligent Transportation Systems applications.
- The FCC should base decisions pertaining to the allocation of the 5.9 GHz on the best-available science and a rigorous cost-benefit analysis. It should account for the contribution to U.S. economic competitiveness when determining what spectrum to dedicate to transportation safety applications, and not solely consider the potential effects on the telecommunications industry.

Proposal: Establish strict oversight of the operation of Chinese-owned telecommunications networks in the United States and implement strict limits on the use of Chinese equipment in U.S. telecommunications networks.

Congress and the President have enacted and implemented policies that largely prohibit use of telecom equipment that poses a national security risk.[542] The FCC has been directed to prepare a list of such equipment, and companies are directed to remove and replace the equipment by deadlines set in the law. The statute establishes a Secure and Trusted Communications Networks Reimbursement Program to reimburse small carriers for the cost of replacing equipment.[543]

The FCC also regulates foreign telecommunications companies that operate in the United States. An interagency group comprised of representatives from the Homeland Security, Justice and Defense Departments advise it on the

536 National Highway Traffic Safety Administration, *Frequency of Target Crashes for IntelliDrive Safety Systems*, U.S. Department of Transportation, October 2010.

537 See, e.g., Amitai Bin-Nun, "Using Fuel Efficiency Regulations to Conserve Fuel and Save Lives by Accelerating Industry Investment in Autonomous and Connected Vehicles," Securing America's Future Energy, April 2018; and Xavier Mosquet, Michelle Andersen, and Aakash Arora, "A Roadmap to Safer Driving Through Advanced Driver Assistance Systems," Boston Consulting Group, September 29, 2015.

538 Consumer Reports, *Safety First: Car Crashes, Innovation, and Why Federal Policy Should Prioritize Adoption of Existing Technology to Save Lives*, June 29, 2020.

539 5G Automotive Association, "White Paper on ITS Spectrum Utilization in the Asia Pacific Region," July 5, 2018; and Elaine Chao, *Re: Draft Notice of Proposed Rulemaking in the Matter of Use of the 5.850-5.925 GHz Band*, The Secretary of Transportation, November 20, 2019.

540 CAR 2 CAR Communication Consortium, Road Safety and Road Efficiency Spectrum Needs in the 5.9 GHz for C-ITS and Automation Applications, December 21, 2018.

541 U.S. Department of Transportation, "Preliminary Testing: Out-of-Channel Interference (Out-of-Band Emissions)," December 6, 2019.

542 See, e.g., Executive Order 13873, "Securing the Information and Communications Technology and Services Supply Chain," 48 Fed. Reg. 22689, May 17, 2019; Federal Communications Commission, "Report and Order," Matter of Protecting Against National Security Threats to the Communications Supply Chain Through FCC Programs," adopted November 22, 2019; H.R. 4988, "Secure and Trusted Telecommunications Act of 2019," 116th Congress March 12, 2020.

543 Ibid.; and Jim Dempsey, "Bans on Foreign Equipment in US Critical Infrastructure," Lawfare, May 19, 2020.

national security risks of such operations. The advisory function, however, is not authorized by statute. This has caused insufficient funding and staffing, delayed reviews, and poor oversight of foreign telecommunication operations in the United States.[544]

Three state-owned Chinese carriers were authorized to operate in the United States in the early 2000s, but have been subject to minimal, if any oversight since. Beijing can use these carriers to support espionage against the United States.[545]

Recommendations

- The FCC must rigorously screen all mobile telecommunications equipment to ensure networks are secure. It must limit use of components from companies or nations that pose a risk to the security of U.S. 5G networks.
- Congress should monitor the Secure and Trusted Communications Networks Reimbursement Program and appropriate additional funding if needed to complete the replacement of suspect 5G equipment.
- Congress should authorize the advisory role of appropriate departments to the FCC regarding the operation of foreign telecommunications companies in the United States, and ensure that the function is appropriately staffed and funded.
- The FCC should establish a clear standard for revoking operating authorization for foreign telecommunications firms, and then carefully review all Chinese operators.
- Future foreign investments in the U.S. telecommunications networks should be coordinated with CFIUS.

Issue #4: Combat Predatory Economic Practices

As important as the vehicle manufacturing sector is to the U.S. economy, the challenges it faces competing with China are part of a larger problem. The United States is in an economic and geopolitical struggle with China for regional and global power. The United States wants to preserve and expand the post-war Western norms that form the foundation of free and open societies, and that have guided nations to interact with each other within a consistent and generally accepted set of practices and principles. The United States wants to compete and trade with our partners, but to do so in a manner consistent with market-based economics. Adherence to these principles promotes peace and economic growth, allowing people to improve the quality of their lives and communities.

Western nations and Japan welcomed China to participate more fully in their economic community when the country joined the WTO in 2001. Those nations hoped that doing so would encourage China to contribute to the stability of Asia, to open itself to the world, and uphold the rule of law at home and abroad. The United States believed that in joining the WTO, China was on a path toward economic freedom; that the more it liberalized its economy, the more it would liberate the potential of its people, and that its people would ultimately demand a greater role in their governance.[546]

China, however, has taken a different path. It has flouted global trade rules, denied foreign companies fair access to its markets while coercing technology transfers, stolen intellectual property, and failed to uphold the rule of law.[547] Beijing operates a surveillance state. It forces its companies—both public and private—to respond to government requests, including sharing electronic surveillance on foreign customers.[548]

Managing this competition will be one of the most important challenges that the United States faces over the coming decades. It will require a full recognition of the problem, a willingness to support U.S. businesses as they compete against Chinese businesses that play by a different set of rules, and a sustained effort to alter Chinese behavior. Because of China's size and influence, the United States will have to work closely with its economic and security allies to confront China in furtherance of common interests. This may require assembling a coalition of allies to address China, likely requiring the United States to reengage the international community on a range of issues.

Proposal: Create a forum for U.S. auto manufacturers and technology developers to work together to address issues related to conducting business with China.

Companies doing business in China face a plethora of challenges and issues in dealing with Chinese companies, the Chinese government, and the Communist Party. Those businesses are operating in a state managed economy that

544 David McCabe, "Senate Faults Oversight of Chinese Telecom Companies in U.S.," New York Times, June 9, 2020.
545 Ibid.
546 See, e.g., George J. Gilboy and Eric Heginbotham, "China's Coming Transformation," Foreign Affairs, July/August 2001.
547 World101, "What Happened When China Joined the WTO?" Council on Foreign Relations.
548 Lauren Maranto, "Who Benefits from China's Cybersecurity Laws?" Center for Strategic & International Studies, June 25, 2020.

lacks certain freedoms that other countries take for granted. To access the Chinese market, foreign companies are often forced to partner with Chinese companies that steal their intellectual property and then become their competitors.

Chambers of Commerce, or other similar organizations, often serve as forums in which businesses with shared interests can network, exchange ideas about working in a particular environment, and advocate for common interests. Such organizations, however, are often limited because of the difficulty in reaching a consensus among large numbers of companies, and in this instance, because of their concern about maintaining a positive relationship with Beijing.

American auto manufacturers, parts suppliers, and other technology developers could benefit from a forum with foreign auto companies in which the global concerns of the auto industry as a whole trump the concerns of particular companies. Such an organization could identify common concerns and share them with the appropriate officials in thier respective governments, or the Chinese authorities as appropriate. It could initiate lobbying campaigns or lawsuits, promote technical standards for vehicles and their components, and share information on how to source Chinese talent without violating U.S. regulations.

Recommendations

- Establish a coordinating body that represents the interests of global automakers, parts suppliers, and automakers based in our economic and security partners' countries, as they relate to China. Such a body would allow automakers to share information on Chinese practices, cooperate to secure access to processed minerals, and advocate and lobby for the setting of global standards that benefit Americans.

- This organization would differentiate itself by focusing on the challenges of conducting business in China, and facilitating coordinated activity in response to Beijing's longstanding divide-and-conquer strategy.

- Congress should grant an anti-trust waiver so that members can share necessary information and act in a coordinated manner.

Proposal: Regulate Chinese investments in the United States that undermine our economic and national security.

In recent years, Beijing has substantially invested in U.S. companies, with a particular interest in the technology sector. Such investments are often part of a deliberate effort to buy the latest U.S. technology by investing in the companies that own it. Often, neither the U.S. government nor U.S. companies know the identity of the beneficial owners of a company with which they might have a business or investment relationship. This lack of transparency facilitates corruption and makes it difficult for companies to avoid engaging in transactions that might undermine U.S. security by selling data, critical technology, or access to U.S. infrastructure to certain Chinese businesses.[549]

The Securities and Exchange Commission requires publicly listed companies to undergo audits pursuant to standards established by the Public Company Accounting Oversight Board (PCAOB). The requirement is intended to ensure a degree of transparency among listed companies, which protects investors. However, almost 300 foreign firms from countries that do not allow disclosure of sufficient information to meet the PCAOB's audit standards are listed on U.S. exchanges.[550] To ensure that all companies listed on U.S. exchanges are subject to a uniform standard of accountability, Congress should require that all foreign companies comply with the audit standards in order to be newly listed, or if they are already listed, meet the standards within a specified period of time or be delisted.

Recommendations

- Require U.S. businesses to disclose beneficial ownership when incorporating so that we have a clear understanding of what foreign influences are participating in our economy.

- Delist foreign companies that do not meet our accounting standards.

Proposal: Renew and strengthen alliances with our economic and security partners to confront China together.

The U.S. economy remains the largest in the world, and its military the most capable. China, however, is the second largest economy in the world with a massive population and the world's second largest defense budget. Moreover, China's size and location provide it substantial influence in Eastern Asia and elsewhere. As the unipolar world that has existed since the collapse of the Soviet Union transforms into a bipolar or multipolar world, U.S. efforts to grapple with China are far more likely to achieve success if pursued in partnership with allies.

China challenges the United States' position in Asia. Many

549 Cory Bennett and Bryan Bender, "How China acquires 'the crown jewels' of U.S. technology," Politico, May 22, 2018.
550 See, e.g., The Editorial Board, "Blackballing Chinese Stocks," The Wall Street Journal, August 10, 2020.

East Asian nations are wary of Beijing's intentions and the potential strings that might come with Chinese funding—even as they see opportunities to engage with China. The United States' success in rebuilding alliances with Asian nations will be predicated on its ability to provide an alternative to Chinese domination by helping them strengthen their economies and institutions—rather than fostering an explicit anti-Chinese bent. The United States' success in promoting its own national interests in healthy, transparent markets and alternatives to China's unfair trading practices will depend on our efforts to strengthen relationships and partnerships across the globe.

To that end, a key challenge and uncertainty is Beijing's "United Front" strategy, which aims to expand the role of the Party in China and globally. A Leninist concept, United Front activities involve strengthening the Party's friends while weakening its enemies, and amplifying the voices of those who support Beijing while suppressing the voices of those who do not.[551] It is a type of elite capture, which works to ensure that key former politicians and business leaders support Beijing and its goals.[552] While United Front work—and its role in the EV, AV, and 5G sectors globally—is not well understood, Chairman Xi regularly calls it a Party priority.[553] United Front work both indirectly, and at times directly, aims to weaken America's alliances with its economic and security partners. The United States and likeminded nations must understand this strategy, so they can fight against it.

Finally, to constrain China's ambitions, the United States must also work closely with other allies and partners in Europe, as well as with Australia, Japan, and South Korea, all of which are developed nations with deep ties to China. Doing so will require the United States to reengage with the international community, recommit to its longstanding alliances and agreements, and capitalize on the tools of soft power to rebuild influence around the world.

Recommendations

- Work with economic allies to develop a consensus and common response regarding China trade and security issues.

- Work closely with U.S. government offices and agencies, including the Agency for International Development, the Export-Import Bank, the Overseas Private Investment Corporation, the U.S. International Development Finance Corporation, and the Department of Commerce's Infrastructure Transaction and Assistance Network, to foster investment, economic growth, and goodwill globally as a counterweight to China's influence.

- Build on the foundation of the United States, Australian, and Japanese led Blue Dot Network, which promotes adoption of trusted standards for quality, global infrastructure development in an open and inclusive framework, especially as it pertains to advanced transportation systems infrastructure.

- Work with multilateral institutions including the World Bank and the Asian Development Bank, whose mandates are to promote local innovation and competitiveness, and to provide support for other nations.

- Counter China's United Front work by studying Beijing's strategy and developing plans to blunt it.

- Reconfirm the United States' commitment to a wide range of multilateral institutions, in order to rebuild trust amongst traditional U.S. economic and security allies; this will serve as a step toward developing a common approach to addressing China.

551 Alexander Bowe, "China's Overseas United Front Work," U.S.-China Economic and Security Review Commission, at page 4.
552 Ibid., at page 10.
553 Ibid., at page 8.

Commanding Heights of Global Transportation
Policy Proposals

1 Support the Advanced Fuel Vehicle Market and Domestic Manufacturing

- Expand current federal incentives for advanced technology vehicles, and update fuel economy and emission regulations, to stimulate adoption.
- Establish incentives for medium- and heavy-duty EVs.
- Support strategic investment in next-generation vehicle manufacturing and their supply chains.
- Invest in nationwide advanced fuel vehicle charging and refueling infrastructure.

2 Develop a Critical Minerals Supply Chain That is Not Controlled by China

- Promote a U.S.-based supply chain for rare earth elements by chartering a cooperative to build and operate an integrated refining, processing, and metallurgical facility. Develop a thorium bank to manage the byproduct of the refining process.
- Support a domestic supply chain for critical minerals.
- Diversify supplies of minerals for which there are not reserves in the United States.

3 Advance Next-Generation Transportation Technologies

- Modernize motor vehicle regulations in order to preserve and strengthen American leadership in AV technology.
- Preserve the 5.9 GHz spectrum band (the "Safety Band") for the exclusive use of connected vehicle technologies.
- Establish strict oversight of the operation of Chinese-owned telecommunications networks in the United States and implement strict limits on the use of Chinese equipment in U.S. telecommunications networks.

4 Combat Predatory Economic Practices

- Create a forum for U.S. auto manufacturers and technology developers to work together to address issues related to conducting business with China.
- Regulate Chinese investments in the United States that undermine our economic and national security.
- Renew and strengthen alliances with our economic and security partners to confront China together.

About SAFE

SAFE unites prominent military and business leaders to develop and advocate for policies that improve America's energy security by significantly curtailing our dependence on oil and promoting responsible use of our domestic energy resources. SAFE relies on the knowledge and experience of four-star retired military officers, Fortune 500 CEOs, and its expert staff to produce high-quality, fact based analysis and policy recommendations for lawmakers, regulatory agencies, and the public.

Armed with a deep understanding of the issues, SAFE leads the conversation on energy and transportation policy with the goal of bolstering America's economic and national security. Agile and multidisciplinary, SAFE maintains a strategic ability to adapt to the rapidly evolving energy and transportation landscape with real-time, up-to-date analysis and recommendations.

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