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'Made in China 2025' and the Limitations of US Trade Policy

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Executive Summary

Made in China 2025 is emblematic of China's 21st century industrial policy, reflecting an unprecedented effort by the largest non-market economy in the history of the world to dominate advanced technologies of the future. Although many nations have industrial policies, none have progressed as fast, nor have devoted resources at such scale.

The economic relationship between the United States and China is significant. About 2.6 million US jobs and $216 billion in US GDP are linked directly and indirectly. At the turn of the century, China was the 11th largest export market for the United States; today it is the 3rd largest.

Nonetheless, US politicans of all stripes see China as a threat to US competitiveness. Of particular interest is trade policy—the rules by which international commerce is conducted. Which policies has China adopted to advance its industrial ambitions? Which policies should the United States adopt to counter China's industrial ambitions? How can the United States counter China effectively while at the same time expanding the fruitful trade relationship that the US enjoys with China?

To answer these questions, we first describe MIC 2025 and China's extensive implementation efforts. Substantial government-directed resources support private-sector efforts consistent with the plan, the heart of which is to acquire advanced technology through six strategies that have raised concerns from competing nations.

We then detail China's efforts to lead in the manufacturing of industrial robots and electric vehicles: two products highlighted in MIC 2025 and for which China is capturing ever-greater market share domestically. MIC 2025 is enabling this progress, although there are signs of inefficiency, especially in terms of government subsidies. And it may be too early to tell if China will lead in pushing the technology frontier outward through indigenous innovation.

We then turn to the policy tools available to US trade officials. We note those wielded by the Trump Administration to date, notably tariffs. We find that existing trade policy tools are insufficient to fully address the challenge posed by MIC 2025.

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We consider four options for US policymakers: (1) develop new and improved domestic trade policy tools; (2) employ policies apart from trade policy to thwart China's aims; (3) engage with allied nations and/or China to develop new trade rules and reform the WTO; and (4) develop a national competitiveness plan that more efficiently leverages American entrepreneurship and innovation, with a focus on R&D investment. All four should be pursued, with the fourth option offering the most promise.

I. Introduction

In terms of international trade, the rise of China has been the defining feature of the 21st century. Fueled by foreign direct investment attracted by low-cost labor and world-class infrastructure suitable for shipping goods anywhere in the world, China became "the world's factory." Between 2001, when it entered the World Trade Organization (WTO), and 2010, China tripled its manufacturing output and, in 2010, overtook the USA as the world's top manufacturing nation (Levinson, 2017). Production of goods became the engine of its growth: China has doubled its GDP every eight years and in so doing lifted 800 million people out of poverty (Morrison, 2019), becoming the world's second-largest economy, behind the United States, and first in terms of purchasing power parity.

The US has reaped enormous benefits from trade with China, especially since China entered the WTO. China was the 11th largest export market for the US in 2000; today it is the 3rd largest. About 2.6 million US jobs and $216 billion in US GDP are linked directly and indirectly to the US-China economic relationship. Many US jobs have been lost due to the US trade deficit with China, but US firms that produce high-valued products have been especially effective at competing in the Chinese market. Prominent examples include motor vehicles, engines, construction equipment and information technology. The trade benefits to the US will be even larger if China continues to open its market to US firms and foreign investment (Oxford Economics, 2017).

China has not achieved success through Western-style capitalism. Its success is due to a carefully orchestrated combination of 'opening up' and communist party control, reflecting "socialism with Chinese characteristics" (Deng, 1984).

As China's economic might surpassed those of other nations, so have concerns about its policies and practices. Critics contend China employs mercantilist policies that promote exports and inhibit imports (e.g., Atkinson, 2016). Others are even more direct—contending that China flouts norms of international trade—that it cheats. (Heering, 2019; Zakaria, 2018; Block, 2019; Friedman, 2019).

Perhaps no single action mobilized China's critics as much as the 2015 unveiling of *Made in China 2025* (MIC 2025): a multi-decade plan to become the strongest manufacturing nation on Earth. So fierce was the opposition from abroad that Chinese leaders stopped citing it in official statements (even as they promoted its aggressive implementation).

In the United States, politicians of both major political parties see China as a threat to US self interest. Donald Trump's get-tough approach to China was front-and-center in his successful 2016 campaign for president, when he accused China of illegal trade activities—even going so far to use the term trade "rape."[4] Four years later, all of the major candidates for President see China as a significant economic threat. According to presumptive Democratic nominee Joe Biden, "If we don't set the rules [on international trade], China is going to set the rules."[5] Most recently, the covid-19 pandemic, which begain in the Chinese manufacturing hub of Wuhan, has highlighted the vulnerability of the United States to global value chains, leading to calls for "re-shoring" of US capabilities (Sobey, 2020).

But to counter China's threat to U.S. competitiveness, more than political will is necessary; policies matter also, policies that enhance US benefits from China trade while also curbing China's tendency to flout its obligations under international trade law. By pointing to imperfectctions in China's trade practices, we are not suggesting that US and European practices are always virtuous. In this report, however, our focus is on the behavior of China and how the US should respond to China's manufacturing policies. Specifically, we ask: Which policies has China adopted to advance its industrial ambitions? Which policies should the United States adopt to counter China's industrial ambitions? How can the United States counter China effectively while at the same time expanding the fruitful trade relationship that the US enjoys with China? These are the questions we seek to answer.

II. Made in China 2025

China's meteoric economic rise in the 21st century has created its own challenges. First, China no longer has an absolute advantage in the making of the most labor-intensive goods because its labor costs have risen rapidly (+10% per year) over the past decade (Sun, 2017). Consequently, many supply chains have been evolving slowly toward nations offering cheaper labor, including some of China's Asian neighbors (Vietnam, Cambodia, Malaysia, and Indonesia) (Barrett, 2019). These other nations are, however, limited in terms of the scale of available labor and raw material inputs.

Second, China cannot alwayscompete with the nations (Japan, Germany, South Korea and the United States) that produce the highest value-added goods due to concerns over the quality of manufacturing. China also has weak systems for protection of intellectual property, which puts both US and Chinese innovators at risk of thievery in the global marketplace.

To alleviate these two pressures and avoid the so-called "middle-income trap" that has plagued some other developing nations, China crafted a plan. Initiated in 2013 as a

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4 In June 2016, presidential candidate Trump laid out his trade policy in a speech in monessan, PA, where he promised to use every legal tool at his disposal to take on China's illegal trade practices. Trump accused China of trade "rape" at a campaign rally in Fort Wayne, Indiana on May 2, 2016.

5 Biden said this at the Democratic Presidential Debate sponsored by ABC News in Ohio on September 13, 2019.

project between the Chinese Academy of Engineering and the Ministry of Industry and Information Technology (MIIT) involving 50 scholars and 100 research experts, this plan—MIC 2025 – was first released on May 8, 2015 by the State Council and endorsed by Premier Li Keqiang. It has been called a signature project for President Xi Jinping (Zenglein and Holzmann, 2019). As Xi described it, "We will move Chinese industries up to the medium-high end of the global value chain, and foster a number of world-class advanced manufacturing clusters" (Kania, 2019).

Perhaps surprisingly, MIC 2025 is China's first national plan promoting manufacturing in general (Ma et al., 2018). As soon as it was released, the National Advisory Committee on Building a Manufacturing Power Strategy was formed, and this group leveraged the work of nearly 500 representatives of academia, industry, and government to develop the *Made in China 2025 Major Technical Roadmap*, also known as the Green Book (US Chamber, 2017). As its name suggests, the Technical Roadmap contains specific performance goals and metrics for a wide variety of advanced manufacturing technologies.

MIC 2025 is based on three central premises (General Office of the State Council, 2015). First, *there can be no national prosperity without strong manufacturing*. China's economy has grown enormously since the turn of the century, largely due to the growth of its industrial sector. With MIC2025, China seeks to continue to leverage, long into the future, domestic manufacturing as its primary driver of economic growth.

Second, *China's manufacturing sector is large but not yet strong* compared to advanced economies. In 2010, China surpassed the United States in the total value of its industrial output. However, its leadership position is threatened by low labor productivity.Through MIC 2025,China aims to improve its labor productivity

Third, *a new industrial revolution is underway that will enable China's manufacturing sector to become strong*. With MIC2025, China seeks to employ smart manufacturing—the digitalization of manufacturing at the production unit, factory, and supply chain levels—to catch up to other advanced manufacturing nations like Germany, Japan, and the United States.[6]

The essence of the China plan is described in its guiding principles:

> *Manufacturing innovation will be the theme, improving quality and performance the core, integration of the next generation IT into manufacturing the main thread, intelligent manufacturing the main priority, and meeting the demands of economic and social development and national defense the goal.*

The plan establishes milestones in 5-year increments. By 2020, China will achieve industrialization and greatly increase manufacturing digitalization. By 2025, the overall

[6] MIC 2025 does not convey the transformational leap required to move a nation from labor-intensive manufacturing to smart manufacturing. The potential for social and political disruption is widely acknowledged by China experts to be high and is no doubt a constraining factor for China's leaders.

quality of manufacturing will improve greatly and the integration of IT into industry will reach an advanced level. By 2035, Chinese manufacturing will reach an intermediary level among world powers. By 2049 (the centennial of the founding of modern China), China will become the world leader among the world's manufacturing powers. In addition to these milestones, the plan includes a few target metrics in terms of innovation capability (e.g., internal R&D cost as a percentage of operating revenue), quality (e.g., average annual labor productivity growth), integration of IT (e.g., broadband penetration), and green development (e.g., reduced greenhouse gas emissions intensity).

The plan identifies nine strategic tasks. Notable among them is improving national manufacturing innovation capability—by building 15 industrial technology research bases by 2020 and 40 by 2025; accelerating the internationalization of Chinese standards in areas like smart manufacturing; cultivating businesses with globally competitive intellectual property rights; and strategically building industrialization-oriented patent pools.

Another task: seeking breakthroughs in ten strategic industries: next generation IT (including AI), high-end digital control machine tools and robots, aerospace and aeronautical equipment, oceanographic engineering equipment and high-technology shipping, advanced rail transportation equipment, energy efficient and new energy vehicles, electric power equipment, agricultural machinery equipment, new materials, biopharmaceuticals and high-performance medical equipment, and high-end equipment innovation projects. According to the US Chamber of Commerce (2017) citing an analysis by Rhodium Group, these industries cover 40% of China's value-added manufacturing.

The plan emphasizes the use of certain policy tools (Malkin, 2018), including finance (e.g., encourage the China Development Bank to increase loans for manufacturing enterprises, widen manufacturing finance channels), intellectual property law (e.g., promoting commercialization of IP rights), regulation (of product quality and de-regulation of foreign investment), fiscal and tax policy (e.g., government purchasing policies, public-private partnerships to allocate capital to major projects, reduce the risk of investing in the first units of major equipment), labor policy (e.g., increase the number of advanced manufacturing engineers, strengthen vocational education and skill training), small business incentives (e.g., financial and taxation policies to support small and micro businesses), and trade and investment policies (e.g., develop guidelines for national treatment of foreign investment, relax controls on market entry, transform the utilization of foreign capital to emphasize joint ventures and collaborative development). Importantly, these policies emphasize a greater reliance on both market forces and governmental intervention.

With MIC 2025, China is largely following the "East Asian development model" that has been successfully employed by Taiwan, Japan, Singapore, and South Korea—the so-called "Asian Tigers"—in which the government chooses particular sectors, sets economic goals/targets, and then ensures alignment of public and private interests (Zenglein and Holtzmann, 2019; Kota and Mahoney, 2020) so as not to rely solely on foreign direct investment (FDI). There are, however, important differences in terms of resources (China's approach is more resource-intensive) and methods (including the mechanism of state direction).[7]

MIC 2025 should not be viewed in isolation. It is a blueprint that (A) is closely related to other national plans that preceded it (e.g., plans to promote indigenous innovation and the Belt and Road Initiative)[8] and (B) it guides all levels of government across China. According to one analysis (Zenglein and Holzmann, 2019), nearly 450 complementary and subsidiary policies/actions accompany MIC 2025. At the national (Communist Party) level, important complementary policies include the Guidelines for Service-Oriented Manufacturing, the Development Plan for the Robotics industry, the Technology Standardization Framework, the national plan for artificial intelligence, the 13th Five-Year Plan (2016-2020), and the Internet+ policy. According to Ma et al. (2018), 29 provinces, autonomous areas, and municipalities have issued specific regional and local policies to implement MIC2025.

Especially noteworthy is *Made in China 2025 Key Area Technical Roadmap*, which provides detailed goals, including global market share targets for each of the ten strategic industries listed in the plan. It was first released in 2015 and updated in 2019 (Zenglein and Holzmann, 2019). For example, the performance target/metric for new energy vehicles was increased after China surpassed its initial target/metric. This reflects an important point: MIC 2025 is not static; it is evolving and changing in reaction to circumstances (Zenglein and Holzmann, 2019).

We see MIC 2025 as emblematic of China's 21st century industrial policy, reflecting an unprecedented effort by the largest non-market economy in the history of the world to dominate advanced technologies of the future. Although many nations have industrial policies, none have made progress as fast, nor have devoted resources of such scale, as China.

When describing MIC 2025, Western observers focus on the ten strategic industries. Less attention has been given to the overall emphasis on smart manufacturing. The specific motivation behind MIC 2025 was Industrie 4.0, a German strategy unveiled in 2013. The name suggests a fourth industrial revolution, one based on digitalization (i.e., connectivity across the value chain) via the Industrial Internet of Things (IIoT). Germany was the first to call attention to this next evolutionary step in manufacturing. In smart manufacturing, China sees an opportunity to leapfrog other nations in technological development (Zenglein and Holzmann, 2019); it doesn't want to miss this

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[7] For a comparative analysis of China and the Asian Tigers, see Arthur Kroeber chapter in Kennedy (2011).
[8] China has, over the years, issued policies to promote "indigienous innovation," beginning with the National Middle to Long Term Plan for Science and Technology Development, 2006 2020. According to Liu et al. (2017), China's national innovation system can be seen in two phases, the first being a top-down, heavy handed approach from the 1980s to 2013 and the second being a more nimble, broad-based approach relying more on markets since 2013. The Belt and Road Initiative, initiated in 2013, involves China-financed and -built infrastructure projects in developing nations around the world in order to expand Chinese influence (Chatzky and McBride, 2020).

chance as it missed the first three industrial revolutions.[9] And because smart manufacturing can benefit all manufacturing firms, China is giving it more emphasis (more policies, more funding) than any of the ten listed strategic industries.

Once issued, MIC2025 quickly drew criticism from competitor nations (Kania, 2019; US Chamber, 2017). MIC 2025 is sprinkled with terms such as "indigenous innovation" and "self-sufficiency." Specific targets for increasing global market share can be found in the *Technical Roadmap* (2017). It is these targets that critics point to when citing China as a threat. China has countered this criticism by downplaying the importance of this document. Some view MIC 2025 as a symbolic, aspirational document rather than an official public policy that will govern its trading relationships with other countries.

Critics foresee China engaging in unfair business practices and/or industrial espionage to acquire foreign technology critical to the plan. When the US Trade Representative (2018) issued its investigative report critical of China's intellectual property (IP) policies and practices, the phrase "Made in China 2025" appeared more than 100 times. A European think tank concluded that China's plan will "challenge the economic primacy of leading economies and international corporations" (Wubbeke et al., 2016).

China reacted to the backlash (which coincided with the US imposition of tariffs on Chinese imports) by scaling back mention of MIC 2025 in official publications by government officials (Crawford, 2019; Zenglein and Holzmann, 2019). It also issued a less incendiary plan in late 2019/early 2020. Yet despite speculation (Behsudi 2019), China hasn't rescinded MIC 2025. In fact, it continues in full swing; implementation is backed by hundreds of billions of dollars of government-directed subsidies, though many of these policies may have occurred without MIC 2025 (Malkin, 2018; Kania, 2019; Zenglein and Holzmann, 2019).

III. China's Technology Acquisition Strategies

Central to MIC 2025 is the acquisition of advanced technology. China employs a particular set of six strategies, which can be categorized as invent (collaborative R&D between industry, government, and academia); incent (subsidies for production and consumption); invite (technology transfer requirements for foreign investment through joint ventures and licensing); impose (through rules or standards); invest (outbound investment in foreign firms); and infiltrate (theft of intellectual property). As Table 1 indicates, each of these six strategies has raised concerns from competitor nations, including the United States (e.g., see USTR 2018). However, the nature of concern differs – in terms of degree and the relative importance China places on each strategy.

[9] The first three industrial revolutions were triggered by steam power, electric power/mass production, and information technology, respectively (Schwab 2015).

Table 1. China's Six Technology Acquisition Strategies.

Strategy	*Example*	*Issue/Concern*
Invent (collaborative R&D)	National Technology Innovation Center for New Energy Vehicles	China is greatly outspending the USA to promote manufacturing innovation
Incent (subsidies)	Dongguan "Replacing Humans with Machines" policy subsidizes factory automation.	Massive government subsidies violate existing trade rules
Invite (technology transfer)	GM required to set up 50/50 joint venture with Chinese firm to build an auto factory in Shanghai.	Forced technology transfer in return for market access.
Impose (regulation or mandates)	New energy vehicle mandate set quota for sales of zero-emissions vehicles from domestic carmakers.	State-directed standards favor China IP over foreign IP
Invest (outbound investment)	Medea purchased German robotics manufacturer Kuka.	State-directed effort to acquire technological knowhow from abroad
Infiltrate (IP theft)	Huawei accused of trying to steal T-Mobile robot, "Tappy."	State-directed IP theft from foreign tech companies

Collaborative R&D. MIC 2025 includes efforts to create manufacturing innovation centers, each of which fosters collaboration in pre-commercial R&D among government, industry, and academia. Each center is strategically located in a region where local manufacturing firms can best leverage its expertise. These centers are apparently modeled after the Manufacturing USA institutes (Nager, 2016), but there are significant differences. For example, the Communist Party awards only one Chinese firm all of the IP developed from each center.

As of December 2019, China had established 13 national manufacturing innovation centers (11 of them are already built and 2 of them are in the process of being completed) with a plan to establish 40 by 2025. These national centers include those with a focus on robotics (National Robot Innovation Center in Shenyang) and electric vehcles (National Technology Innovation Center for New Energy Vehicles) (China Daily, 2018). In addition, each Chinese province is establishing its own innovation centers. As of mid-2019, China had established 107 such centers at the provincial level. They are in some ways similar to the US collaborative research centers that foster an ecosystem for advanced manufacturing, such as the Commonwealth Center for Advanced Manufacturing in Virginia.

Critics contend that China's government is investing and facilitating these collaborative innovation centers at a level that dwarfs US government investment in its Manufacturing USA program (Molnar, 2019). This is a criticism of the United States more than a criticism of China.

Subsidies. Subsidies represent by far the most common policy tool we uncovered. For example, of the policies or policy announcements related to industrial robots (see

Appendix), all 55 of the provincial and municipal level policies involve governmental subsidies.

And the magnitude of Chinese subsidies is substantial, leadingcritics to contend that such massive government subsidies represent an unfair business practice and violate rules of international trade. Some studies contend the subsidies are on the order of tens of billions per year; others suggest that they have accumulated to hundreds of billions of dollars since 2015 (Zenglien and Holtzmann, 2019; Hancock and Jia, 2019). According to Scott Kennedy of the Center for Strategic and International Studies, "This data just reinforce the impression that Chinese companies start the race for business far ahead of their competitors."

<u>Forced Technology Transfer</u>. Prior to joining the WTO, China explicitly required foreign firms to partner with a Chinese firm in order to access the large Chinese domestic market. Upon joining the WTO, China withdrew these written requirements, but critics (US Trade Representative, 2018) contend that the practice continued in some sectors (e.g., aerospace).

Automobiles provide an historical example. When China first opened up its economy to foreign automakers, it cut a deal with GM to form a 50/50 JV with a Chinese auto company and build a state-of-the-art factory (including top-line industrial robots) in Shanghai, forcing other foreign automakers (e.g., Volkswagen) to upgrade their factories (Bradsher, 2020) in China to keep pace. Today, China is the world's largest market for automobiles, and nearly all of them are made domestically using advanced industrial robots. China, on the other hand, is frustrated that Chinese automakers have not progressed enough through joint ventures to compete globally on their own. Even in the Chinese market, much of the revenue and profit from car sales in joint ventures is captured by global automakers such as GM and VW.

Other examples of forced technology transfer include wind turbines and solar panels (Bradsher, 2020), two products where China holds the largest global manufacturing share.In 2005, China required that 70% of every installed wind turbine to to be made in China. Foreign firms that dominated the market then trained Chinese suppliers to make every component. Later, after the policy was rescinded due to international pressure, Chinese firms produced identical turbines at lower prices.

International criticism has led China to announce, in recent years, an end to forced technology transfer. The "Phase I" trade deal negotiated with the United States, which was announced in December 2019 (US Trade Representative, 2020b), establishes a written commitment on this point. But ensuring compliance will be difficult because explicit government policies have been replaced by informal requests made at the local level—often by the domestic JV partner firm. For a foreign firms seeking a foothold in the massive Chinese market, it may prove difficult to refuse such requests. In certain situations, some sharing of technology with Chinese firms may be in the commercial interests of the foreign company, so it is difficult to sort out when technology transfer is legitimate and when it is coerced.

Aside from joint ventures, China has also used its administrative licensing requirements to force the transfer of technology in return for market access (US Trade Representative, 2018). China's licensing rules differ for domestic Chinese firms than those for foreign firms (e.g., all indemnity risk must be borne by the foreign entity).

Regulation/Standards. China's government imposes rules that all manufacturing firms must follow. For example, China's new energy vehicle (NEV) mandate sets a quota for the number of zero-emission vehicles that its carmakers must sell, with each vehicle earning a certain number of credits, depending on characteristics such as energy efficiency and power (Steer, 2018). The precise timing and characteristics of the quotas can be tweaked by regulators in ways that favor some manufacturers over others.

Another form of regulation is through technical standards, which are specifications, in the form of rules or guidelines, for materials, products, processes, or services (such as communication between machines, systems, hardware, and software). Standards often are based on technologies that embody intellectual property (IP). Technical standards govern the flow of information within and across a firm and its supply chain, enabling smart manufacturing—the "main priority" MIC 2025. By 2035, China aims to become the world leader in development of technical standards.

According to Belton et al. (2019), China recognizes the strategic importance of global technical standards—and the IP embedded in such standards. At the beginning of this century, its manufacturing sector utilized standards based on intellectual property owned by foreign firms. This approach led the country to seek low royalty payments in exchange for market access. Over time, as its economy grew and its manufacturing firms became more sophisticated, China shifted its strategy. Its government now participates actively in global standard-setting bodies that are of strategic importance. And it is aggressively writing standards for emerging technologies to benefit its own firms.

With respect to industrial robots, China has issued 51 technical standards (tallied from the standards directory for robotics) since the publication of MIC 2025, according to the National Robotics Standardization General Working Group of China (2020). In addition, between 2016 to 2019, China's national robotics standardization general working group has also initiated a total number of 53 standards programs (from the standards plan catalogue), 40 of which are exclusively designed for industrial robots.

Outbound Investment. Several studies (Wubbeke et al, 2016; EU Chamber of Commerce, 2017; EU Commission, 2017; US Chamber of Commerce, 2017; US Trade Representative, 2018) have found that Chinese outbound investment is not based solely on market factors; the Chinese government often directs the acquisition of foreign firms to achieve its technology goals, including those in MIC 2025. This strategy is outlined in official statements; the State Council (General Office of the State Council, 2016) called for its state-owned enterprises (SOEs) to acquire forward-looking industries. Such statements prompted the EU Chamber of Commerce (2017) to ask: "Does MIC 2025 in part amount to a shopping list of technologies that the country has not been able to develop at home?" On the other hand, there is nothing inappropriate about the Chinese government helping Chinese companies identify firms outside of China that are good prospects for investment, joint venture or acquisition. In recent years, Chinese firms' planned US investments have become the largest source of filings before the Committee on Foreign Investment in the United States (CFIUS)—an interagency group tasked with reviewing foreign investments that may erode US national security.

With respect to industrial robots, the Chinese consumer products company Medea acquired, in 2016, the leading German robotics maker Kuka, giving China one of the top ten global manufacturers of industrial robots, and facilitating the MIC 2025 goal of developing three national champions in industrial robotics (Kuka, 2016).

IP Theft. According to the US Department of Justice (Demers, 2018), China is using a variety of means, including various forms of economic espionage, to advance MIC 2025 at the expense of the United States. From 2011-2018, more than 90% of the US Justice Department's claims of economic espionage to benefit a nation involved China, and more than two-thirds of ongoing US trade secret cases involve China.

For example, in *United States v. Huawei* (2019), the Chinese company Huawei is alleged to have sought IP related to "Tappy," T-Mobile's quality control robot that performs "touches" on smartphones at the factory to determine responsiveness, performance, and stability of the interface. In this case, the Chinese government is not listed in the indictment. However, in other cases, the United States has implicated the Chinese government, and the target was often a US manufacturer of advanced technology, including cases involving jet engines and dynamic random-access memory (DRAM) (Demers, 2018).

Our point in describing these strategies is to indicate concerns that have been expressed by the United States and other nations. We note that China has defended the legality of its strategies (with the exception of IP theft) and that other nations, including the United States, have employed many, if not all, of these same strategies during the course of its history.

In the next two sections, we describe China's efforts to lead in electric vehicles and industrial robots, respectively. These products represent two of the ten industrial sectors identified in MIC 2025. We chose these two to illustrate potential differences based on type of technology: one is a consumer product, the other an industrial product. We also chose these cases because China has focused on each of them for many years. Insofar as China's efforts to lead in these products pre-dates issuance of MIC2025, then MIC2025 may be seen as a reaffirmation or strengthening of previous policy initiatives. For each, we describe the strategies that China is employing to realize its vision, the setbacks China has experienced, and the progress that is being made.

We find that China is making progress in both product categories, especially in serving its domestic market. Its progress in exports is less significant. Policy is enabling this progress, though there are signs of inefficiency, especially in terms of government subsidies. And it may be too early to tell if China will lead in pushing the technology frontier outward through indigenous innovation.

IV. Electric Vehicles

For decades, Chinese economic planners have craved the development of an auto industry that is globally competitive, one that includes both assembly plants and a supporting auto parts sector. If truly competitive, the industry would export vehicles and parts to countries around the world while also meeting the growing needs of Chinese consumers. For at least 25 years, the Chinese vision has been a handful of "mega" vehicle manufacturers and another handful of mega parts suppliers. China is openly envious of what Toyota has done for Japan, what Volkswagen did for Germany, and what General Motors did for the United States.

Before Made in China 2025: Emphasis on NEVs

At the beginning of the 21st century, China's Ministry of Science and Technology operated the 863 Program, an applied R&D program involving Chinese auto makers, suppliers, universities, and independent laboratories (Shier, 2018). The Ministry, convinced that China had little hope of competing with Japan, Korea, Germany and the United States in conventional propulsion systems (diesel and gasoline), shifted its focus to "New Energy Vehicles" (NEVs), especially plug-in electric vehicles (PEVs), both purely battery-electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs). China's hope was to "leap frog" over the established global auto makers by securing a first mover advantage on PEVs. The "leap frog" idea did not become policy instantly; it evolved over the decade from 2010 to 2020.

China's R&D on lithium ion batteries (LIBs) and electric drive systems started in 2000 about 10 years behind Japan but, in roughly five years, the gap was closed to less than 2 years, primarily due to the 863 Program, the rise of China in consumer electronics, and the emergence of BYD Company Ltd., a successful battery maker for consumer products that entered the auto sector as a privately-owned company in 2003. A turning point for NEV policy occurred in 2007 when Wan Gang, a former Audi engineer who earned his Ph.D. in Germany, was named Minister of Science and Technology, the first cabinet minister from a non-Communist party in modern times. He held the post for a decade and was influential in persuading Chinese politicians to launch China's national industrial policy toward PEVs.

Starting in 2009-2010, four Chinese ministries collaborated on several city-based NEV demonstration programs where subsidies were provided for PEVs. The manufacturer set the suggested retail price, sold the vehicle for that price minus the subsidy, and then billed the government for the amount of the subsidy. Matching subsidies were supplied by host provinces and municipalities, which made each NEV even cheaper for the purchaser. The program hosts were predominantly eastern cities where major Chinese automakers are located (headquarters and facilities). The demonstration program started in ten cities (2010), was then expanded to an additional 25 cities (2012), and then 39 more, for a total of 74 cities by 2015.

Evaluations of the early PEV demonstrations reported mixed results. The cities are difficult to compare because they enacted different mixes of pro-PEV policies and incentives. PEVs were generally well received by motorists but consumer uptake in cities fell short of the goals set for the demonstrations; some cities participated only to gain access to central government funding, without a serious long-term commitment to PEV deployment (Wang et al., 2019).

Fear of the US and Japanese Policies

The Great Recession of 2007-2009 provided political support for an effort by the Obama administration and key California Democrats to pour billions of dollars in grants and subsidized loans into several companies and partnerships in the nascent US PEV sector. The beneficiaries, among others, were Tesla-Panasonic, Fisker-A123, General Motors-LG Chem, and Nissan-NEC Corporation. A $7500 consumer tax credit was also provided for purchasers of a qualified PEV. To further stimulate the nascent US PEV industry, the Obama administration, through the Department of Energy, launched the "Electric Vehicle Project", which provided grants to about a dozen US cities for subsidized PEVs, free charging stations, and consumer education about PEVs. In the 2008-2012 period, the US market witnessed the launch of the Nissan Leaf (a BEV), GM's Chevrolet Volt (a PHEV), Tesla's Roadster sports car and Model S sedan (both BEVs), and Fisker's Karma sports car (a PHEV). The Obama Administration also assisted GM and Chrysler with emergency loans and a structured bankruptcy process to weather the downturn in the financial markets. GM used some of that support to finance the Volt.

Japanese industrial policies were moving in a different direction. Unimpressed by the promise of LIBs for automotive applications, the Japanese government, aligned with the views of experts at Toyota and Honda, promoted conventional hybrid electric vehicles (HEVs) in the short run and hydrogen fuel cell vehicles (FCVs) in the long run (Soble, 2018). From 1990 to 2015 the Toyota Prius (HEV) was a startling commercial success, first in Japan and later in the United States and then in Europe. In California alone, the Prius was the number one selling car in 2012 and 2013. On the R&D front, Japan moved into a leadership role on hydrogen R&D, and developed a bold long-term plan to shift the entire Japanese economy (homes, industry, electric power and transportation transportation) to hydrogen. This "hydrogen society" is ambitious but implementation has been slow (IEA, 2019b).

Wang and his allies among Chinese planners and politicians saw the US and Japanese policies as a potential competitive threat to China's NEV initiative (Ball, 2019). A large-scale industrial policy focusing on national PEV deployment was seen as an urgent priority in China (Graham et al., 2013).

A $15 billion national NEV policy for China was first released in draft form by the Ministry of Industry and Information Technology in early 2010 (World Bank, 2011). The final draft of the plan, adopted in late 2010, dropped the $15 billion figure and provided few fiscal details. The central government of China has never published an itemized accounting of all subsidies provided to the PEV sector.

The central government's original goal was to put 5 million electrified vehicles on the road by 2020, 2.5 million PEVs, and 2.5 million HEVs. Like the State of California and the US federal government, China later dropped the policy promotion of HEVs and recast the national goal as 5 million PEVs by 2020. (Actually, the Chinese policy is to promote NEVs, a category that includes hydrogen FCVs. However, PEVs are expected to dominate the country's NEV industry until at least 2030). The diminished interest in HEVs partly reflects the fact that such vehicles use a mature technology and partly the reality that Japan already has a first-mover advantage on HEVs.

The key feature of China's NEV policy was nationwide NEV subsidies modeled after the subsidies administered in the demonstration cities. The subsidy program was coupled with four important changes in auto-sector policy that boosted the fortunes of Chinese PEV, battery, and component producers. The new policies were not adopted all at once but were rolled out gradually between 2012 and 2015 (mostly prior to, yet consistent with, MIC 2025).

First, the central government "requested" that foreign auto companies working in joint ventures with Chinese auto makers share PEV technology with Chinese automakers. The Obama administration complained that this policy was a violation of the terms of China's 2001 entrance into the World Trade Organization. China disputed the allegation, emphasizing that it was a voluntary policy, without any compulsion on foreign auto makers. The issue was never taken to the WTO.

Second, the central government and provincial/city governments made NEV subsidies available only to Chinese automakers. Foreign companies exporting PEVs to China (e.g., Tesla) were not only subject to China's tariff on imported cars; they were also ineligible for PEV subsidies. Some foreign companies operating through joint ventures with Chinese companies were able to access NEV subsidies when the PEV was assembled in China by a Chinese partner. Some provincial/city NEV subsidies were made available only to Chinese auto companies located in the province/city, a practice that the central government discouraged.

Third, the Chinese Ministry of Industry and Information Technology published from 2015 to 2018 a list of approved Chinese suppliers of LIBs. If a Chinese automaker did not use one of those suppliers, the automaker's PEV was declared ineligible for NEV subsidies. The combination of central government and provincial NEV subsidies ranged from $10,000 to $20,000 per vehicle, depending on the city and the PEV design. For Chinese producers of LIBs, especially Contemporary Amperex Technology Limited (CATL) and BYD, the approved supplier list was a huge boost for their business development in China. Korean and Japanese battery producers, even though they were investing in Chinese facilities, were effectively excluded from the Chinese market in those years.

Finally, Chinese banks helped Chinese suppliers gain access to raw materials for LIBs and electric-motor production. China possesses some -- but not all -- of those key raw materials (e.g., lithium, cobalt and neodymium). Chinese banks, working closely with the central government, enabled Chinese suppliers throughout the PEV supply chain to acquire ownership interests in companies and mines everywhere from Australia and Africa to South America, North America, and Europe. Recent studies show that Chinese companies have a dominant or influential position in most of the raw materials and components (anodes, cathodes, electrolytes, and separators) that are inputs to LIBs, electric motors, and PEVs (FP Analytics, 2019).

Made in China 2025: Reaffirmation of National NEV Policy

Released in 2015, Made in China 2025 should be seen as a reaffirmation of China's pro-NEV policies that were developing gradually over the previous ten years (Kong, 2016). Since the national NEV subsidies were adopted prior to the emergence of China's new leadership team in 2013, MIC2025 was also seen as a reaffirmation of pro-NEV policy by the new leadership. There is no question, though, that MIC2025 gave additional impetus to China's national PEV policies.

The national goals for PEV deployment have been upgraded and extended to 2025, when PEV sales are expected to reach 3 million *per year,* 80% of which will be produced by domestic Chinese automakers (Ren, 2018). Currently, PEV sales in China are running around 1 million per year. The extent of PEV subsidies have extended far beyond the original $15 billion figure; independent estimates place the cumulative amount of subsidies, from 2011 to 2018, at roughly $60 billion (Kennedy, 2018; Kennedy and Qiu, 2018). This figure includes producer subsidies, foregone tax revenue, subsidies for charging infrastructure, and governmental R&D.

PEV Sales and Production

In 2019, PEV sales in China were approximately 1.18 million units (80% BEVs and 20% PHEVs), or about 5.5% of the country's new passenger vehicle market. By way of comparison, the PEV market shares were 1.9% in the US and 3.6% in Europe. PEVs tend to be assembled in the same country/region where they are sold, so new PEV sales are roughly equal to PEV production (IEA, 2019a).

PEV sales are not distributed equally throughout the US, Europe or China. Sales of PEVs in the United States are dominated by California, where the 2019 PEV market share was 8.0%; the highest PEV market share in Europe (and the world) was in Norway at 42.4%; and PEV penetration in China is concentrated in the large eastern cities. California is the location (Fremont) where most Tesla vehicles were assembled in 2019 but Tesla now has a large new facility in Shanghai. Norway does not have any major vehicle assembly facilities. China's auto makers are concentrated in the eastern cities.

In contrast to the US market, where PEV sales are predominantly premium Tesla models (especially the Model 3 executive sedan), the top selling PEV models in China cover a range of vehicle types and price points, with a concentration in the small, affordable segment (Ou et al, 2019). Table 2 compares the five best PEV sellers in China to the top five in the US market, with descriptions of each model. The prices for the Chinese offerings are after applicable subsidies; the prices for the US offerings are prior to applicable federal and state consumer subsidies. The US subsidy situation is complicated because Tesla and GM have exhausted their access to federal subsidies, and some states provide subsidies only to vehicles priced below a certain level.

Table 2: Top-Selling PEV Models in China and the United States.

CHINA	United States
• BAIC EU-Series (111,047 units)—formerly the Beijing Senova D50 EV; 4-door compact sedan; $18,430+.	• Tesla Model 3 (158,925) – premium (executive) sedan; $40,000+.
• BYD Yuan (67,839) – subcompact crossover; 5-door hatchback; $11,200+.	• Toyota Prius Prime PHEV (23,630) – compact car; 5-door liftback; $28,530.
• SAIC Baojun E-series (60,050)—from SAIC-GM-Wuling joint venture; microcar; 2-seat hatchback; $7,697+.	• Tesla Model X SUV (19,225) – luxury mid-sized SUV; 7-seats; $84,990+.
• Chery eQ (39,401) – minicar; 5-door hatchback; $9,600+.	• Chevrolet Bolt (16,418) – subcompact; 5-door hatchback; $36,620.
• BYD Tang BHEV (34,084) – mid-sized crossover; 5-door SUV; $48,000+.	• Tesla Model S sedan (14,100) – luxury sedan; 5-door liftback; $79,900.

Sources: Kane (2020a, 2020b). For information on individual models, see their Wiki entrees, Edmunds.com; and manufacturer web sites.

China has not always had a larger PEV market share than the United States. China actually trailed the United States from 2010 to 2014 but then surpassed it in 2015 and has widened its margin ever since (Graham et al, 2014; International Energy Agency, 2019). Europe was slow to develop its PEV sector but it is now growing much faster than the US and China sectors.

Is China Liberalizing its PEV Policy?

During the last five years, China has made several strategic decisions that suggest that it is liberalizing its PEV policies, which will make them more defensible in the WTO. The central government is phasing out NEV subsidies and and providing a more level playing field for PEV and LIB producers around the world.

In 2015 China announced that it would gradually phase out subsidies for PEVs from 2016 to 2020 (MOST, 2015). Provincial and municipal subsidies are required to be phased out at the same pace as – and in proportion to -- the central government subsidies. As the subsidies have been reduced, they have also been reformed to encourage advanced PEVs that have a longer all-electric driving range. The final termination of subsidies was recently delayed until at least 2022 due to the unexpected downturn in the Chinese auto sector, which began prior to the COVID-19 pandemic. The turbulence added by COVID-19 could lead to a further extension of PEV subsidies, as China's PEV sector plummeted in the first quarter of 2020. Although subsidies to PEV producers have already declined substantially, the central government has transferred some of the budgetary savings to increasing subsidies of PEV charging infrastructure, especially "fast charging" along highways that connect the country's eastern cities.

The central government's interest in curbing PEV vehicle subsidies was accentuated by several factors that emerged in the 2015-2020 period: a government investigation found a significant amount of producer fraud in the subsidy program (Bhattachorya, 2016); the subsidies were causing a proliferation of new small-scale PEV producers, which runs counter to the country's consolidation objective in the auto sector; nonfinancial incentives (especially the PEV exemption from vehicle licensing restrictions in large eastern cities) were potent in promoting PEV sales (IEA, 2019a); and the United States Department of Commerce cited the subsidy programs in the Trump administration's report on China's unfair trade practices (Coffin and Horowitz, 2018).

In April 2018, the central government also announced that it is phasing out long-standing requirements (since the 1990s) that compel foreign automakers, when working through joint ventures with Chinese auto makers, to share factory ownership and profits with Chinese corporate partners (Fusheng, 2019). Starting in 2018, foreign automakers making PEVs in China are not required to work with a Chinese automaker. By 2022, the joint venture regulations for all motor vehicles will be scrapped. Some experts viewed this action as a gesture to reduce tensions with the Trump administration on automotive trade (Moss, 2018). In any event, Chinese policymakers began to lose confidence in the joint-venture policy more than a decade ago, since it did not seem to be effective in building a robust and globally competitive auto sector in China.

The timing of the deregulation of joint ventures also coincided with the maturation of Tesla's plan to build a huge PEV production complex in the Shanghai free trade zone (Moss, 2019). Without a China facility, Tesla has had difficulty accessing the China market, since China has been enforcing a WTO-sanctioned 25% tariff on all imported cars. Tesla began production of PEVs in Shanghai at the end of 2019. Originally, Tesla planned to produce LIBs at the same complex but the company has since announced battery-outsourcing plans with CATL, China's largest LIB producer, and the Korean battery maker LG Chem, which is expanding production facilities near Shanghai. It appears that Tesla products will also be eligible for the diminished level of subsidies for PEVs until the Chinese subsidy program is finally terminated.

In conjunction with the phase out of PEV subsidies, the central government announced a new NEV mandate (Vinkhuyzen, 2019). Effective April 2018, a California-style "zero-emission vehicle" mandate will be applicable to all auto makers doing business in China (ICCT, 2019). Each auto maker is required to earn NEV "credits" equal to 10% of their overall China sales in 2019 and 12% in 2020. Much to the disappointment of the Japanese government, no credits are awarded for HEVs. The number of NEV credits for each PEV varies based on whether it is a BEV or PHEV and other vehicle characteristics.

Foreign auto makers were irritated by the short lead-time since Chinese companies are better positioned to offer PEVs in the short run than foreign automakers, which have been ineligible for the country's PEV-producer subsidies (unless they work through a

Chinese partner) (Moss, 2017). Until the mandate, companies such as Toyota, Honda, Ford and Daimler had only limited plans or no plans to offer PEVs in China. Recently, each of these companies has announced new plans to offer PEVs in China, usually with Chinese partners (e.g., Toyota and BYD have signed a cooperation deal) (Whitley and Futonaka, 2019).

In 2019, China's Ministry of Industry and Information Technology quietly stopped listing approved LIB producers on the Ministry's web site. As a result, PEV producers will not be required to source their LIBs with Chinese battery makers. This move is seen as a near-term boost for LG Chem, Samsung, and Japanese LIB producers that have been interested in expanding their LIB exports to -- and production in – China. The decision was announced in the context of a wide range of "government management reforms" but it is widely seen as increasing international competition to help China consolidate its battery- and auto-producing sectors. An unspoken advantage of the plan is that it may make it easier for CATL and other Chinese LIB producers to export LIBs to Europe and North America and to expand joint ventures elsewhere in the world with foreign automakers such as VW, BMW, Toyota, and Honda.

China's PEV Policies from a Trade Perspective

The development of China's PEV sector is off to a robust start due to public policies that are provocative from an international trade perspective. Subsidies for China's PEV sector were focused almost entirely on companies headquartered in China. While all industrial subsidies are suspect from a trade perspective, the design of the Chinese PEV subsidies are even more discriminatory than the subsidies handed out by the Obama administration in 2009-2010. The US subsidies of its nascent PEV sector were awarded to Japan's Nissan-Renault (for a huge new complex in Smyrna, Tennessee) and LG Chem (for a new LIB plant outside Detroit) as well as US startups and the Big Three. Moreover, the US consumer tax credits for PEVs are available to any automaker doing business in the US, regardless of where the company is headquartered or where its PEV assembly plants are located. China's policy on approved battery suppliers, which appeared to be a direct outgrowth of Made in China 2025, was a blatant effort to favor Chinese over South Korean and Japanese battery producers.

In recent years, China has pared back several of the most trade-provocative policies. Looking forward, however, Chinese companies (e.g., BYD and CATL) will retain a competitive advantage globally from the pro-PEV policies that have expired, as it will take non-Chinese companies a great deal of time and resources to compensate for the favoritism that Chinese companies have enjoyed.

Despite all this national favoritism, China has not yet demonstrated that it can produce PEVs that will sell in Europe, Japan, or the United States.[10] What China has demonstrated is that it can dominate (or at least influence strongly) the global supply chain for PEVs, including LIBs, components, and raw materials. The United States,

[10] It may be important to note that China's policies may eventually produce large volumes of exported goods. Steel and solar panels are examples of products where China's policies eventually—over decades—led it to become the the leading exporting nation.

Europe, and Japan have yet to muster effective policies to counter China's supply chain strategy.

More than 100 auto companies operate in China, most of them state-owned, but – until recently – they have not been technological innovators. Instead, they thrive – or at least survive -- based on supportive relationships with their host provincial and city governments (e.g., local governments purchase taxi fleets from local automakers). Several national state-owned enterprises produce large numbers of new vehicles and they are belatedly becoming a factor in the market for PEVs. The most intriguing development in the sector has been the emergence of private companies such as BYD, Geely, Zotye, and Great Wall.

Is China helping or hurting itself with its strong pro-PEV policies? A more technologically-neutral, incentives-based approach to innovation (e.g., higher fuel taxes) might be better in the long run. Even Wan Gang, often considered the father of the modern PEV in China, has cautioned against putting all of the country's eggs in the LIB basket. He believes that China should also be developing a robust fuel-cell vehicle industry (Bloomberg, 2018c).

V. Industrial Robots

Specific Goals of MIC 2025

Approximately 80% of China's industrial robots can be found in the manufacturing sector (Cheng et al., 2019). Certain kinds of industrial robots (intelligent robots) are also a leading indicator of smart manufacturing. It is not surprising then that MIC 2025 lists industrial robots and high-end CNC machines as one of ten targeted sectors.

Among its stated goals for robots:

> "actively research new products and promote robotic standardization and market application modularization in order to meet the demand for industrial robots in the automotive, machinery, electronics, chemicals, and light industry, specialty robots and service robots in medical treatment, domestic services, education and entertainment. Remove the bottleneck of essential spare parts such as robot bodies, reducers, servomotors, controllers, sensors, drivers, and integrated system design."

At the same time, China proposes to "make breakthroughs" in core components of industrial robots such as servomotors and reducers; build smart factories to apply industrial robots and other technologies central to Industry 4.0; and "replacing people with robots in key positions" (General Office of the State Council, 2015).

Moreover, according to the robot industry plan announced in 2016 (Ministry of Industry and Information Technology, 2016), China aims to boost annual output by 2020: more than 50,000 units of industrial robots with six axes or above and at least 100,000 units of industrial robots from Chinese-owned brands.[11] It aims to increase its robot density to at least 150 units per 10,000 workers. These goals are likely related to the known density rates in other leading manufacturing nations (see Figure 5).

The numerous metrics that China has announced for industrial robots address two fundamental goals of MIC 2025: (1) to elevate the average performance of its manufacturing base and (2) to ensure that Chinese-owned firms are among the top global leaders. In the former case, China aims to increase its industrial robot density overall, increase its robot utilization in key industries, and raise the quality of its domestically manufactured robots and key components to match that of other leading manufacturing nations. In the latter case, China aims to create at least three national champions and nurture at least five supportive industrial clusters (that is, regional hubs for robot manufacturing).

Background on Industrial Robots

According to the International Organization for Standardization (2012), an industrial robot is a mechanical device that can be "fixed in place or mobile for use in industrial automation application." More specifically, it is "an automatically controlled, multipurpose manipulator programmable in three or more axes." According to the International Federation of Robotics (IFR 2019), an industrial robot is "capable of being adapted to a different application with physical alteration [of the mechanical system]" and "designed so that the programmed motions or auxiliary functions can be changed without physical alteration." In other words, industrial robots replicate a human worker's movement to perform routine, skilled, or high-risk assignments in a manufacturing setting with significant accuracy and efficiency.

Figure 1 shows an articulated robot, which looks and functions like a human arm. Five major components include the manipulator, controller, programmable pendant, reduction gear (i.e., the precision reducer), and servomotor; the latter two (not shown because they are inside the robot) account for roughly 60% of its cost of production (Wubbeke et al., 2016). The precision reducer itself represents 36% of the cost of production of an industrial robot (Global Industrial Speed Reducer Market Outlook, 2019). It is important to note that the cost of implementing an industrial robot may be many times higher than its production cost, especially if the robots are integrated to enable smart manufacturing (Seidelson, 2020).

Kawasaki Heavy Industries (2018) provides a helpful description of these robot components. The manipulator is the robotic arm that can position itself according to the task's demands. The controller is the "brain": it issues operational commands to the manipulator. The programmable pendant is an instrument that is used to coach the manipulator on how to behave.[12] Reduction gear connects the power sources (servo motors) to the actuator (i.e., the joint) to simultaneously reduce the speed and intensify

[11] These numbers are modest if China aims to be a world leader. Millions of additional robots will be required to achieve top status.
[12] This example is for a single robot not integrated into a smart factory. In a smart factory, CAD software is uploaded to CAM packages in lieu of a programmable pendant (Siedelson, 2020).

the output torque (i.e., power). The servomotor is the engine that monitors the speed and positional accuracy of the robot body. Not shown is the end effector—analogous to the fingers of a human hand—that can be swapped out depending on the robot's function.

Although Chinese firms supply most controllers for domestic use, the nation's manufacturing sector relies heavily on imports (mostly Japan) for precision reducers: only 40% of reducers are domestically made (Xinhua, 2019). Similarly, China's development of the industrial robot-related core algorithm is still in the early stages (Science and Technology Daily, 2018). Therefore, foreign giants such as ABB, Fanuc, and Yaskawa currently hold a strong grip over global market share (Wubbeke et al, 2016).

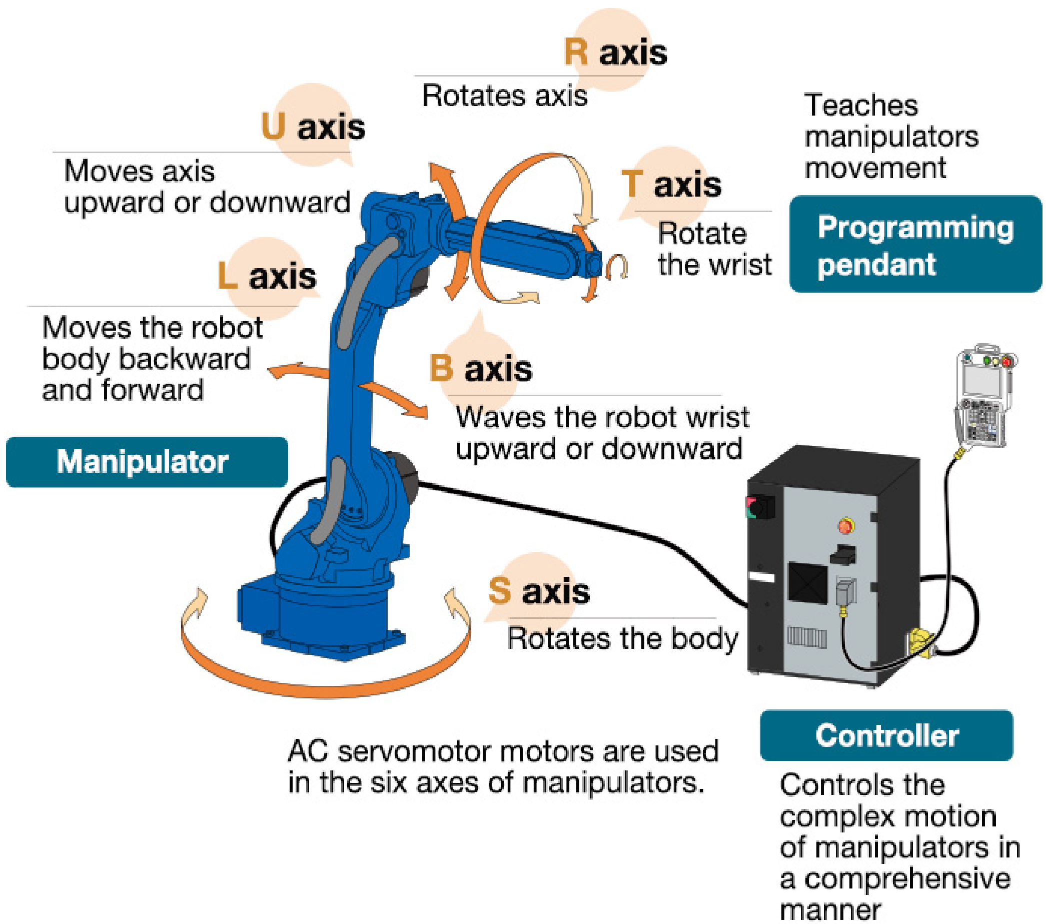

Figure 1. Key Components of a Six-Axis Industrial Robot. Source: Kawasaki

The industrial robot supply chain consists of an upstream of raw materials, mostly including steel, cast iron, aluminum alloy, plastic, and other various electronic elements; the manufacturing of key parts such as servo motors and end effectors; the design and assembly of the robot corpus; and the implementation of system integration (PingAn Insurance Corp, 2019).

Progress To Date

Publicly available data suggest China is improving its relative position in industrial robots in accordance with its two goals: (1) to elevate the average performance of its manufacturing base and (2) to ensure that Chinese-owned firms are among the global leaders.

Progress on the first goal is reflected in China's annual demand for industrial robots and its annual production of industrial robots. Both metrics show a significant upward trend in recent years. In 2018, China installed more industrial robots than all of the other nations on earth combined (International Federation of Robotics, 2019). As shown in Figure 2, China has also increased its production from 32,996 units in 2015 (National Bureau of Statistics of China, 2016) to 177,000 units in 2019 (National Bureau of Statistics of China, 2020). Its installed base of industrial robots (operational stock) has also continued to rise, suggesting that robots are being added faster than they are being removed (International Federation of Robotics, 2017) (see Figure 3).

Figures 4 and 5 illustrate China's robot density per worker. China's rise in robot density is particular striking: from 25 per 10,000 employees in 2013 to more than 140 units per 10,000 employees in 2018 (Figure 4), reflecting an average growth rate of 40% (International Federation of Robotics, 2018). China remains just below its goal of 150 units per worker and well below the leading nations of the world (International Federation of Robotics, 2019) (Figure 5).

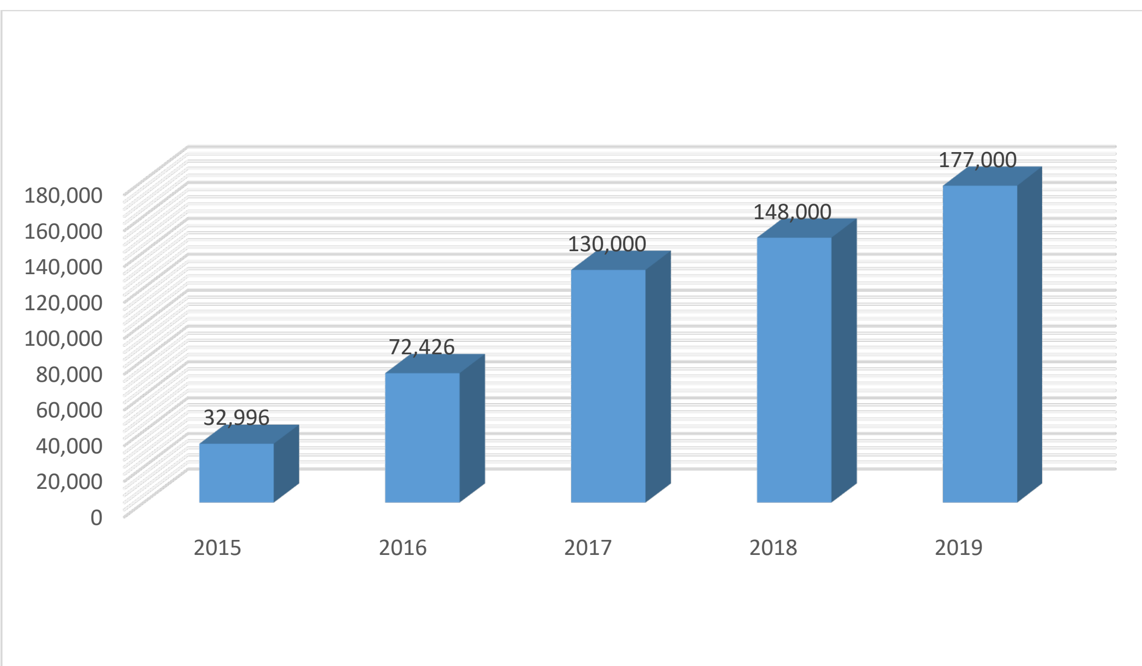

Figure 2. Domestic Production of Industrial Robots in China.

Source: National Bureau of Statistics of China.

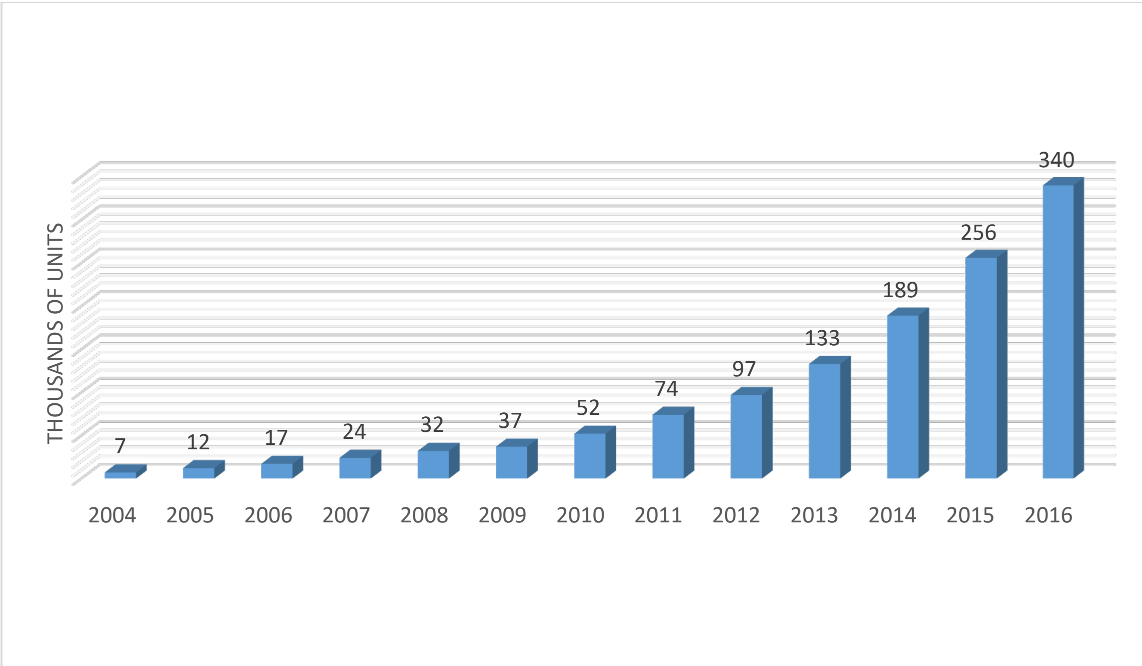

Figure 3. China's operational stock of industrial robots has increased dramatically in recent years.
Source: International Federation of Robotics, 2017.

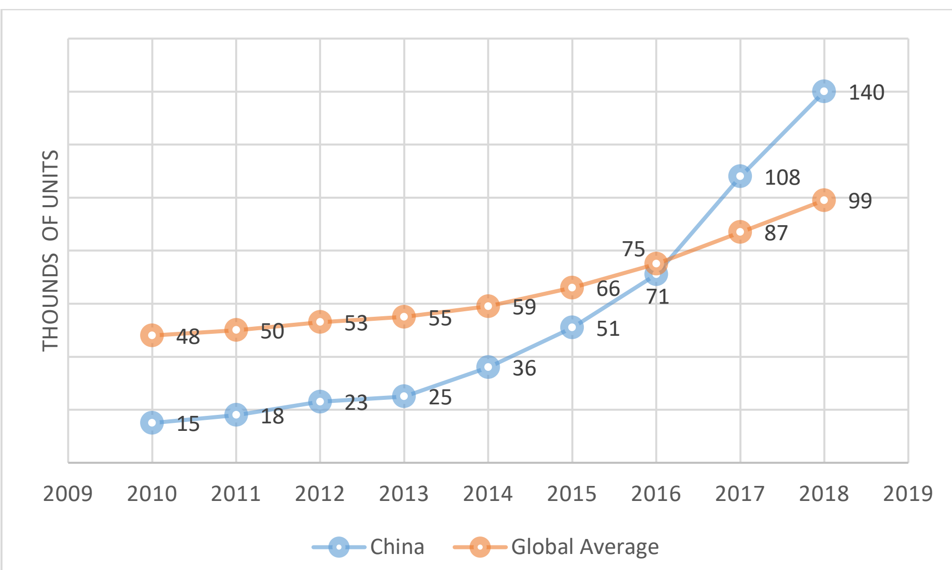

Figure 4. Robot density in China in recent years.
Source: International Federation of Robotics, 2019.

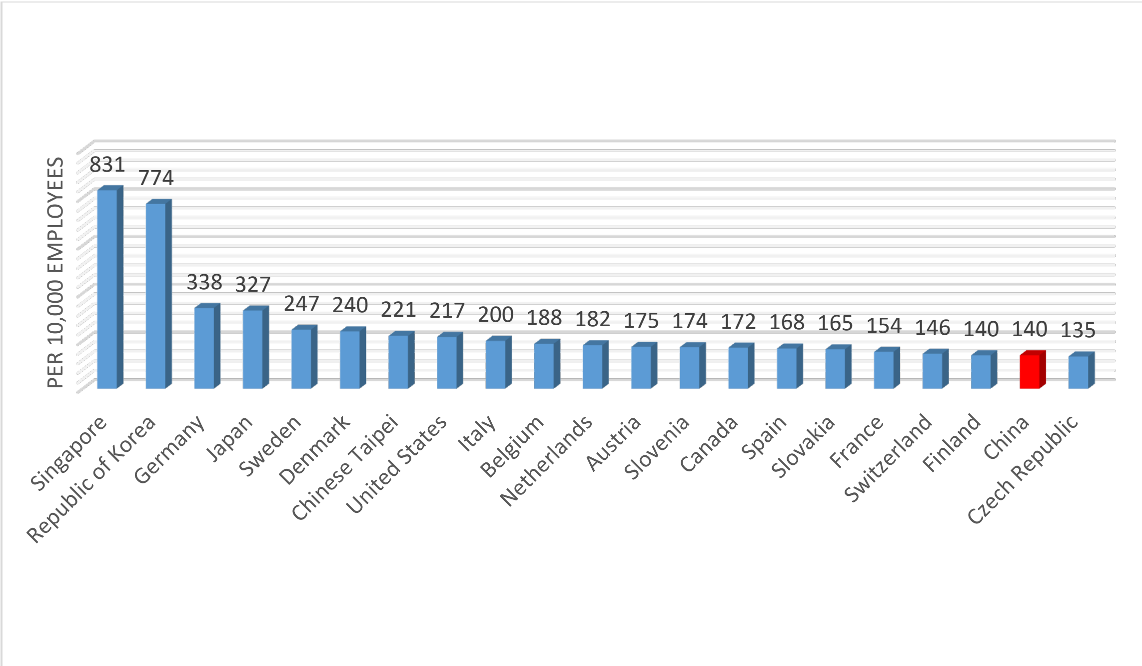

Figure 5. China ranks well below other nations in industrial robot density. Source: International Federation of Robotics, 2019.

Research by Cheng et al. (2019) showed that China's robot adoption is becoming more widely dispersed and not as concentrated in those sectors where it was most common, such as automobiles, electronics, and packaging. Industrial robots are gaining favor in new energy, high-end equipment, warehousing and logistics, and other emerging fields.

With respect to its second goal—global leadership—progress has been mixed. On the positive side, Chinese patents are up. As of December 2017, China had submitted 111,306 patents/applications in the field of industrial robots, accounting for 36.5% of the total amount filed globally (National Intellectual Property Administration, 2018). Most of these patents/applications are for manipulator and the controller system, the driving mechanism ranks the third popular category, and the sensor has the least number of patents/applications. Of the Chinese patent applicants for industrial robots, corporations/enterprises are the main force of patent applicants, accounting for 67.9% of the total number of patent applications, followed by universities and colleges, accounting for 18.7% of the total number of patent applications. However, patent data from China can be misleading, government incentives encourage patents, and a high percentage of the filed patents are of relatively low-value.

However, dependence on foreign technology is still strong. China continues to strategically invest in foreign corporations and encouraging joint ventures with technology leaders, it continues to depend on imports to meet domestic demand, and it continues to publicly acknowledge its technological deficiency (General Office of the State Council, 2019). Compared to Japan's strong position in value-added components

(International Federation of Robotics, 2017) and South Korea's long-standing reign in robot density (International Federation of Robotics, 2019), China is far behind.

Particular challenges facing China relate to the development of next-generation technologies for industrial robots: collaborative robots (cobots) and AI-enabled robots (Wubbeke et al, 2016). Some observers believe MIC 2025, with its emphasis on upgrading existing manufacturing capabilities, is ill-suited to inspire indigenous innovation for industrial robots. Whereas China excels in producing low-cost robots, due in part to government subsidies, high-end robots remain a distant capability.

Implementation of MIC 2025

Are the noted trends in robot usage and production due solely to market forces? Evidence suggests the answer is no; government policies are also important. We turn now to those policies and practices that have been employed by China to acquire technological know-how in industrial robots under MIC 2025. Subsidies are by far the most prevalent, distorting markets and international trade.

Market Forces and Government Policies

In 2016, Cheng et al. (2019) surveyed a representative sample of Chinese manufacturing firms and manufacturing workers (the China Employer Employee Survey) in two manufacturing-intensive provinces (Guangdong and Hubei) to explain the rise in production and consumption of industrial robots in recent years. They confirmed that the distribution of robots in China is similar to robot distribution globally; the leading subsectors are automotive, electronics, and metal production.

Their survey results show that a combination of market forces (i.e., the rising price of labor) and governmental policies (i.e., subsidies) influence the firm-level adoption of robots. With respect to governmental factors, 15% of all robot-using firms received a government subsidy for their use of robots, and firms where the CEO was politically well-connected (a member of the Communist Party) had a slightly higher probability of using robots than firms without such a connection. (SOEs were less likely to use robots for reasons that were unexplored in the study.)

With respect to market forces, firms paying higher wages had a greater probability of utilizing robots. Interestingly, non-voluntary turnover was not related to robot use, suggesting no relationship between robot adoption and layoffs of workers. Robots were more likely to take over tasks involving manual labor—those that are physically rigorous and often dangerous. The survey also showed that employees did not feel threatened by the firm adoption of robots or by governmental policies to encourage robot adoption. Consistent with the survey, firms were driven to adopt robots for reasons of safety, quality, and efficiency. The covid-19 pandemic may be further pressuring firms to adopt robots for safety reasons.

China's Policy Tools

As noted in Table 1, China employs a particular set of technology policies and practices associated with its economic rise, including some practices labeled unfair trading practices.

We searched for evidence of these policies and practices with respect to MIC 2025 in general and industrial robots in particular. We paid special attention to governmental websites in manufacturing-intensive regions (ten provinces and nine municipalities within those provinces, as well as one additional municipality, Tianjin, that is under the direct administration of the PRC's central government). See Table 3.

Table 3. China's Manufacturing-Focused Provinces and Muncipalities.

Province	*Muncipality*
安徽 (Anhui)	洛阳 (Luoyang – Henan)
福建 (Fujian)	长沙 (Changsha – Hunan)
广东 (Guangdong)	东莞 (Dongguan – Guangdong)
河北 (Hebei)	佛山 (Foshan – Guangdong)
河南 (Henan)	广州 (Guangzhou – Guangdong)
湖北(Hubei)	深圳 (Shenzhen – Guangdong)
湖南 (Hunan)	苏州 (Suzhou – Jiangsu)
江苏 (Jiangsu)	烟台 (Yantai – Shandong)
浙江 (Zhejiang)	嘉兴 (Jiaxing – Zhejiang)
山东 (Shandong)	天津 (Tianjin)

We found 82 distinct policies promoting industrial robots: 27 issued at the national level, 31 from the provincial level, and 24 from the municipal level. (See Appendix for a descriptive list).

Subsidies represent by far the most common policy tool we uncovered. Of the 82 distinct policies or policy announcements we found (see Appendix), all 55 of the provincial and municipal level policies involve governmental subsidies.

One type of subsidy adopted by multiple regions/municipalities is "Replacing Humans with Machines." The city of Dongguan provides an example. In late 2015, Sharif and Huang (2018) observed the effort to automate at nine manufacturing firms and four suppliers, in Dongguan—a major exporting city located near Hong Kong with a population of 2 million and 4 million migrant factory workers. Five of the nine manufacturing firms received subsidies under the Dongguan "replace people with machines" policy. All of the firms felt a need to automate because of a variety of factors (including a tax on exports equal to half of the cost of imported raw materials, a stronger currency, rising energy costs, and more stringent environmental and labor regulation) the most important of which was an escalation in the minimum wage for labor. The researchers also interviewed 63 stakeholders, including government officials.

The policy—which began in August 2014—involved subsidies for 10%-15% of the cost of automation (including but not limited to industrial robots) that replaces manual labor while improving quality. It was targeted toward small and medium enterprises. Government officials acknowledged the subsidy would assist firms that were planning to automate anyway. Two years of the subsidy resulted in the loss of 190,000 jobs and raised labor productivity by more than 200%. Executives from the firms investing in automation listed three driving market-related factors: productivity improvement, quality improvement, and reduced worker injuries.[13]

One of the consequences from China's extensive subsidy programs is an increase in robot-producing firms. According to Cheng et al. (2019), the rapid rise in robotic firms in China (from 221 firms in 2005 to 6,478 in 2015) is largely due to the presence of government subsidies. In 2016, government subsidies were reported to be responsible for 40% of the profits of the four publicly traded robot manufacturers (SIASUN, Estun, Guangdong Topstar Tech, and Shanghai Step Electric) (Lin, 2018). In fact, without government support, Estun would have suffered losses in 2015 (Wubbeke et al, 2016).

Interestingly, most of the robotics firms in China are not providing the value-added services envisioned in MIC 2025. According to one report (He and Chen, 2018), out of thousands of Chinese robotics companies, only about 100 firms could mass produce high-end industrial robots or components such as servo motors, controllers, and speed reducers. Furthermore, the high value-added robots of the future—AI robots and cobots—require different components than those of today. If true, China's subsidies are inefficient or perhaps altogether misguided.

The global pandemic that began in 2019 in Wuhan, China—a major manufacturing region—has led some Chinese localities to sweeten the subsidies for industrial robots to avert future supply chain disruptions. For example, Xiangcheng district, a municipality within the city of Suzhou, changed its subsidy program from retrospective (reimbursement) to prospective (up-front payment) (Bureau of Industry and Information Technology for Xiangcheng District, 2020). Local authorities decided to hand out specific subsidies to any qualified enterprise that will undergo and complete the technological transformation between February and June 30.

With respect to outbound investment, the Chinese consumer products company Medea acquired, in 2016, the leading German robotics maker Kuka, giving China one of the top ten global manufacturers of industrial robots, and facilitating the MIC 2025 goal of developing three national champions in industrial robotics (Kuka, 2016).

<u>Are China's Industrial Robot Policies Working?</u>

Although market forces (notably the rise in labor wages) played a significant role in advancing China's domestic and global market share in industrial robots since 2013, governmental actions (collaborative R&D, subsidies, technical standards, and outbound

[13] The study did not address the question of whether the displaced workers were able to find employment elsewhere. In China, government approval is needed for any labor market restructuring of significant magnitude, of which this policy would seem to apply.

investment) have also made a significant difference. China has made the most progress in the adoption of robots across its domestic manufacturing sector by keeping costs low; less progress has been made in its global market share where high-end robots are in greater demand. The most value-added components of industrial robots utilized in China continue to be imported, mainly from Japan.

The intention of MIC 2025 is to move China up the ladder in terms of strong manufacturing, by increasing the number of domestic manufacturing firms utilizing robotics and by advancing the frontier of knowledge in robotics through the creation of national champions. China has made significant progress on the former and some progress on the latter. Policies have certainly assisted in its achievements—but its success may be temporary once subsidies are removed. And there is an opportunity cost to this progress: China has sacrificed efficiency for speed in terms of its industrial policy. And it remains an open question, however, whether China can demonstrate indigenous innovation in terms of advanced robotics technology, including high value-added components (e.g., reducers) and value-added robots. This is particularly important with respect to future technological advancements in collaborative robots and AI-enabled robots. It is, perhaps, too soon to tell if its considerable investments in collaborative R&D will pay off.

VI. US Trade Policy Tools

International trade is influenced by trade policy at the international and national levels. At the international level, trade agreements—multilateral, plurilateral, regional, and bilateral—create norms of behavior that are expected to limit the actions of signatories to the agreements. For example, the United States and China are both members of the World Trade Organization (WTO) and are bound by its rules—although the rules differ for China, which joined the WTO when it was a developing country. At the domestic level, federal laws and regulations set boundaries for the actions of US policymakers. Among the most important statutes are the Tariff Act of 1930 and the Trade Act of 1974, both of which have been amended numerous times.

US policymakers seeking to counter policies and practices of another country that adversely impact US citizens are constrained by the policy tools available to them. With respect to MIC 2025, these trade policy tools include (1) the WTO Agreement; (2) domestic laws allowing for trade remedies (antidumping, countervailing duties, and safeguards); (3) Section 232 of the Trade Expansion Act of 1962, as amended; (4) Section 301 of the Trade Act of 1974, as amended; (5) Section 337 of the Tariff Act of 1930, as amended; and (6) the recently signed Phase I agreement between China and the United States. Table 4 provides a brief description of these policy tools, upon which we now elaborate.

Table 4. US Trade Policy Tools.

Authority	*Focus*	*Lead US Agency*	*Initiation*	*Typical Timeframe*	*Result*
WTO Agreement	violation of WTO Agreement	USTR	Complaint by USTR	2-3 years	suspend concessions to allow retaliation
Section 701 of the Trade Act of 1930	illegal subsidy	ITA and ITC	Petition from an affected industry or self-initiated	9-13months	tariff based on subsidy margin
Section 731 of the Trade Act of 1930	Dumping	ITA and ITC	Petition from an affected industry or self-initiated	9-13 months	tariff based on dumping margin
Section 201 of the Trade Act of 1974	import surge	ITC	Petition from an affected industry or self-initiated or by Congress. Requires Presidential decision.	9-12 months	tariff or quota or other quantitative restriction on global imports
Section 232 of the Trade Expansion Act of 1962	imports threaten to impair national security	BIS	Petition by an interested party or self-initiated. Requires Presidential decision.	12 months	tariff, quota, or negotiated outcomes
Section 301 of the Trade Act of 1974	violation of a trade agreement or policies that are unjustifiable and burden commerce	USTR	Petition by an interested party or self-initiated	6 months or 12 months	tariffs, quotas, or negotiated outcomes
Section 337 of the Tariff Act of 1930, as amended	violation of intellectual property rights	ITC	Petition or self-initiated	12-18 months	exclusion order
Phase I trade deal between United States and China	Certain long-term barriers to trade, including intellectual property, technology transfer, macroeconomic policy and exchange rates	USTR	USTR works with China to ensure that commitments are met	depends on how quickly China responds	negotiated outcomes or additional tariffs

Sources: Atkins and Pan, 2010; Barbour, 2010; Hirsch, 2017; Jones, 2017; Fefer, 2020; Fefer et al., 2019; and Schwarzenberg, 2020.

The WTO Agreement

According to the Council on Foreign Relations (McBride, 2016), the WTO is “the principal forum for setting the rules of international trade.” Established in 1995 as the successor to the General Agreement on Tariffs and Trade (GATT), its founding principles include openness (reduce barriers to trade), nondiscrimination, predictability, and flexibility for less-developed countries. More than 97% of world trade is generated by its 164 members (McBride, 2016).

All multilateral agreements negotiated during the Uruguay Round are binding on all WTO members, including the agreement on antidumping and the agreement on subsidies and countervailing measures (ASCM). No member is supposed to take unilateral action on dumping or illegal subsidies against another member unless in accordance with these WTO agreements (Barbour, 2010).

The WTO dispute settlement mechanism (DSM) has been employed frequently. As of December 2019, 592 disputes had been filed. The mechanism involves a three-step process: consultation, panel and Appellate Body review, and implementation (Shedd et al., 2012). Most disputes have been settled at the first step, consultation. Any member may seek consultation with another member on any “measures affecting the operation of any covered agreement taken within the territory” of the other member. If the dispute is not resolved within 60 days, the complaining member may request a panel, which typically consists of three persons with expertise in the WTO agreements. The panel hears the case and issues an interim report followed by a final report. If a report is adopted by the WTO Dispute Settlement Body, then members who are parties to that case are expected to bring their practices into compliance with the findings of the report. The Dispute Settlement Body, which consists of representatives of all WTO Members, will adopt a final panel report unless all Members disagree with the report, or a disputing party appeals to the WTO Appellate Body. Since the winning party can always be expected to agree with the report, adoption of reports is generally automatic absent an appeal.

Decisions of the Appellate Body will generally be adopted by the Dispute Settlement Body unless all parties object. In recent years, there have been several cases in which the United States has taken the position that certain decisions purportedly issued by the Appellate Body are not entitled to this sort of deference, because the decisions were signed by Members of the Appellate Body whose term had expired or which had other procedural defects.

If a disputing member believes the defending party is not complying with a decision that was adopted by the Dispute Settlement Body, that member may request a compliance panel. Compliance panel reports are also subject to appeal to the Appellate Body. At the end of the process, the complainant member may seek to suspend concessions (that is, retaliate) with respect to the defending country. Suspension of concessions typically involves suspension of tariff concessions on selected products from the non-complying country. The entire process of the DSM typically takes 2-3 years (Rich, 2011).

According to an analysis of all WTO cases, Rich (2011) found that most cases are settled at the consultation stage, that complainants typically win (89% of the time) at the panel and appellate levels, that most nations comply at the implementation stage. She found that China has complied with every suspension requests filed against it. However, USTR (2020d) reported that "{e}ven though the United States has routinely prevailed in these WTO disputes, as have other WTO members in their disputes against China, they take years to litigate, consume significant resources, and often require further efforts when China resists complying with panel or Appellate Body rulings."

In disputes that involve WTO agreements, WTO members are not supposed to take matters into their own hands without first going through the dispute settlement process (Vinik, 2017), in accordance with Article 23 of the dispute settlement understanding (DSU) (Shedd et al., 2016). Critics contend the ASCM is deficient because the definition of a subsidy (e.g., must be from a "public body") is too narrow, the evidentiary burden (e.g., causation) is too high, the notifications provision is often ignored (i.e., nations often fail to report on their domestic subsidies as required), and the remedy is too weak (e.g., a CVD may simply push desired imports from China to another country) (Bown, 2019b). USTR (2020b) has recently complained that the Appellate Body has interpreted the ASCM in a manner that makes it difficult for Members to adequately address the problem of subsidized imports from China.

The United States has been one of the harshest critics of the Appellate Body (AB), arguing that its decisions too often have been at odds with the language of the DSU (Ferguson, 2019). Starting in 2017, the United States has refused to allow vacant seats on the seven-member AB to be filled. By December 2019, there were six vacancies on the AB. Given that at least three members of the AB must be present for a quorum, a quorum is no longer available and the AB cannot function. The DS system is currently in limbo.

US Antidumping Law

US antidumping (AD) authority is found in Title VII of the Tariff Act of 1930, as amended. These laws allow for the imposition of duties on imports of certain goods if: (1) those goods are sold at less than fair value and (2) the goods cause or threaten material injury to the domestic industry that makes a product like the imported product, or materially retard the development of such a domestic industry. The U.S. International Trade Commission (ITC) determines if subject imports have threatened or caused material injury or material retardation. The International Trade Administration at the U.S. Department of Commerce (ITA) determines the existence and amount of dumping, which determines the size of any antidumping duty.

The length of time necessary for a complete AD investigation will be affected by numerous factors, including statutory deadlines and the extent to which the issues are contested. However, as a general matter, AD investigations are normally completed within 9 to 13 months.

After five years, an AD order is subject to a "sunset review." In this review, the ITA must decide whether, in the absence of trade relief, dumping would be likely to resume. The ITC must decide whether, in the absence of trade relief, material injury would be likely to continue or recur (Jones and Christopher, 2019).

It is important to note that AD actions are subject to WTO dispute settlement resolution (Jones and Casey, 2019).

Critics contend that the (non-market economy) methodology imposed by the US against China to determine dumping unfairly increases the calculated antidumping margin (Morrison, 2019a), and that the imposition of an AD duty may simply shift imports to a third country (Felbermayr and Sandkamp, 2020). On the other hand, USTR has complained that the Appellate Body has interpreted the WTO agreements in a manner that makes it more difficult than it should be to impose antidumping duties on unfairly-traded imports.

US Countervailing Duty Law

US countervailing duty (CVD) authority is also found in Title VII of the Tariff Act of 1930, as amended. These laws allow for the imposition of duties on imports of certain goods if: (1) those goods benefited from government subsidies and (2) the goods cause or threaten material injury to the domestic industry that makes a product like the imported product, or materially retard the development of such a domestic industry. As with the antidumping laws, the ITC determines if subject imports have threatened or caused material injury or material retardation. The ITA determines the existence and amount of subsidies, which determines the size of any countervailing duty.
The length of time necessary for a complete CVD investigation will be affected by numerous factors, including statutory deadlines and the extent to which the issues are contested. However, as a general matter, CVD investigations are normally completed within 6 to 13 months.

After five years, a CVD order is subject to a "sunset review." In this review, the ITA must decide whether, in the absence of trade relief, subsidies would likely resume. The ITC must decide whether, in the absence of trade relief, material injury would be likely to continue or recur.

In practice, domestic industries seeking relief often ask for both AD and CVD duties on the same imports. While both types of relief may be imposed on the same imports, ITA has procedures designed to avoid punishing the same company twice for the same behavior.

CVD actions may be challenged at the WTO (Jones and Christopher, 2019). In recent years, USTR has expressed concerns that the WTO's Appellate Body has interpreted the WTO agreements in a manner that would unfairly limit the potential effectiveness of US CVD laws.

AD and CVD duties are often extremely effective against unfair trade. However, there are situations where the imposition of AD and/or CVD duties on imports from one country (or group of countries) leads to a surge in imports from other countries not subject to relief.

Section 201 of the Trade Act of 1974 (19 USC 2251 et seq.)

This law, also known as a "safeguard" provision, is intended to provide temporary relief for a domestic industry subject to competition from a surge of imports to give the domestic industry time to adjust (Jones, 2018). US law provides that in a safeguard action, the ITC must determine whether an article is being imported into the United States in such increased quantities as to be a sustained cause of serious injury, or the threat thereof, to the domestic industry producing an article like or directly competitive with the imported article. If the ITC reaches an affirmative determination, then the President shall take "all appropriate and feasible action" to facilitate efforts by the domestic industry "to make a positive adjustment to import competition and provide greater economic and social benefits than costs."

Under this provision, a finding by the ITC in favor of the domestic industry may result in duties on imports from around the world -- but the decision of what relief to impose (if any) is left to the discretion of the President.

Safeguard actions may be initiated via a petition from an interested party, or by Congress at the request of USTR. Such actions may also be self-initiated by ITC. If a domestic industry asks for safeguard relief, it will also be required to submit a plan for industry adjustment during the period covered by the requested safeguard.
In a safeguard action, the ITC follows a two-step process. First, it reaches a decision about whether the imports at issue represent a sustained cause of serious injury or the threat thereof. If the Commission makes an affirmative determination on this point, it then goes on to develop a remedy recommendation for the President (Jones, 2018). Because a presidential decision is required, Section 201 actions are relatively rare.

The WTO Agreement on Safeguards specifically provides for WTO Members to grant safeguard relief. The WTO's Appellate Body, however, has historically taken a narrow view of safeguard actions (Vinik, 2017). In fact, USTR has long complained that the Appellate Body's interpretation of the Agreement on Safeguards seeks to place too many restrictions on the ability of Members to use safeguard measures.

The Trump Administration's recent use of Section 201 to address imports of solar panels and washers led Kurland (2019) to suggest that Section 201 may be an attractive trade remedy tool because, compared to AD or CVD duties, safeguard measures can be imposed globally, avoid an investigation into an unfair trade practice, and allow limited grounds for a legal challenge. However, such measures entail greater evidence of injury and uncertain review by the WTO.

Section 232 of the Trade Expansion Act of 1962 (19 USC 1862)

This law provides for the Secretary of Commerce to undertake investigations to determine whether "an article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security." Section 232 investigations may be initiated upon request from a federal department of agency or interested party, or they may be self-initiated by the Secretary. (Fefer and Jones, 2020).

Section 232 investigations are conducted by the Bureau of Industry and Security (BIS) at the Department of Commerce. Such an investigation may last up to 270 days. If the Secretary of Commerce determines that the statutory requirement has been met, and the President concurs, then the President shall "determine the nature and duration of the action that, in the judgment of the President, must be taken to adjust the imports of the article and its derivatives so that such imports will not threaten to impair the national security." Because a presidential decision is required, Section 232 actions are relatively rare. Adjustments to import volumes are typically brought about through the use of a tariff or quota.

Section 232 gives the president broad powers and some observers believe that it was intended for use in an emergency situation (for example, see Vinik, 2017). Prior to the Trump Administration, there were 26 Section 232 investigations, 13 positive recommendations, and 6 presidential actions (Fefer and Jones, 2020). The Trump Administration has initiated investigations using this authority five times (Fefer and Jones, 2020). Before the Trump Administration, Section 232 authority had not been used since 1986 (Fefer and Jones, 2020).

President Trump has used the authority granted under Section 232 to impose tariffs on imports of steel and aluminum. Critics contend that these actions stretched the definition of "national security" beyond congressional intent, employing its authority to address a long-term problem (the global oversupply of steel and aluminum resulting from China's excess capacity) not otherwise amenable to other trade remedies. Other nations have challenged Trump Administration's 232 actions at the WTO, arguing that the US is violating Article I (nondiscrimination) and Article II (tariffs exceeding the upper limit) of the General Agreement on Tariffs and Trade (Fefer and Jones, 2020).

<u>Section 301 of the Trade Act of 1974 (19 USC 2411 et seq.)</u>

This law authorizes USTR to impose trade sanctions on nations that violate trade agreements, act in ways inconsistent with trade agreements, or take actions that are unjustifiable and burden or restrict US commerce. The law also allows trade sanctions against a country for "an act, policy, or practice" that "is unreasonable or discriminatory and burdens or restricts US commerce." Such actions may include failing to protect intellectual property rights (Barbour, 2010).

Pursuant to these statutory provisions, USTR first undertakes an investigation to determine whether a nation's actions or policies meet the standard for relief. If so, USTR may suspend concessions, restrict imports, or negotiate an agreement with the offending country to eliminate or phase out the offending actions or policies. USTR may also choose not to take action (Barbour, 2010).

Section 301 actions may be self-initiated or triggered by a petition from an interested party. Investigations can take 30 days (for violations of a trade agreement) or 6 or 12 months (for other violations). Section 301 allows for a variety of potential responses. Retaliatory actions can take many forms, including a tariff or other quantitative restriction, denying trade agreement rights to the offending country, and denying access to the US market (Barbour, 2010).

Before the WTO, the United States regularly used Section 301 to press its trading partners to address US concerns. However, when the United States joined the WTO, the law was changed to make clear that if the actions at issue violated a trade agreement -- and the trade agreement contained a dispute settlement process -- then USTR should pursue relief under that process. Thus, as a general matter, if a country violates the WTO Agreements, or any other trade agreement, USTR is obliged to rely on the dispute settlement mechanism in those agreements, rather than Section 301. However, separate relief under Section 301 remains available in situations where a country has acted in a manner that allows for such relief, but does not violate a trade agreement.

Since joining the WTO, use of Section 301 relief has been relatively rare outside of the WTO dispute settlement process (Barbour, 2010; Hirsch, 2017; Bown, 2017; Vinik 2017). However, the Trump Administration used Section 301 to impose significant tariffs on China after its investigation determined that China was engaged in unfair practices -- such as forcing U.S. companies to enter into joint ventures with Chinese partners -- that did not violate the WTO. Some critics contend the Trump Administration has undermined the WTO by employing this trade policy tool. They have also expressed concern that use of Section 301 has spurred a trade war with China.

Section 337 of the Tariff Act of 1930 (19 USC 1337)

This statutory provision is focused on unfair imports and is used to enforce US intellectual property (IP) rights against imported goods. The ITC has responsibility for enforcing Section 337. It does so by responding to a petition from an interested party to investigate and determine whether imported goods violate IP rights. The ITC may also self-initiate an investigation. There must be a domestic industry for ITC to make a positive finding.

The majority of investigations involve patents, trademarks, or trade secrets. Petitions are typically resolved in 12-18 months. The ITC has the authority to order injunctive relief (e.g., preventing imports from entering the country, typically through an exclusion order) and do not involve damage awards (Atkins and Pan, 2010). US Customs implements decisions made under this law.

Phase I of US-China Agreement

On February 14, 2020, the "Economic And Trade Agreement Between The Government Of The United States Of America And The Government Of The People's Republic Of China," known as the Phase I agreement, went into effect. This agreement was the result of negotiations between the United States and China that took place after the United States imposed tariffs on imports from China pursuant to Section 301.

The Phase I agreement involves a number of new commitments by both countries, with chapters on intellectual property, technology transfer, and macroeconomic policy and exchange rates. In other words, the agreement is designed to address certain long-standing commercial barriers that have made it more difficult for U.S. companies to do business in China. The agreement also involved a commitment by the United States to lower certain tariffs that had been imposed under Section 301, as well as commitments by China to significantly increase purchases of goods from the United States. In addition, the agreement created a bilateral evaluation and dispute resolution process to allow each nation opportunity for further negotiations apart from the WTO dispute resolution process (US Trade Representative, 2020a).

Some critics contend that the deal does not do enough to address the structural issues at the heart of the Trump Administration's concerns with China as outlined in its Section 301 report (Amaro, 2020). Bown and Lovely (2020) claim the deal will harm US long-term interests by strengthening state-owned enterprises inside China. Supporters maintain that the Phase I agreement has the potential to lead to significant structural changes and more efficient market competition between the United States and China.

VII. Limitations of US Trade Policy

China's MIC 2025 aspirations represents a long-term threat to US manufacturing. In a number of key market segments, government entities in China are pouring very large resources into building companies and developing products that make it practically impossible for US companies to compete at scale.

In this paper, we have supplied detailed information regarding China's efforts with regard to electric vehicles and robotics -- two market segments that will likely play a significant role in the future of the global economy. US policymakers face the difficult challenge of how to respond to China's efforts, especially since some of China's policies seem inconsistent with the terms of China's entrance into the WTO.

Unfortunately, none of the major statutory tools to address unfair trade practices was designed to respond to a program like MIC 2025. In fact, there are significant limitations to each.

WTO Dispute Settlement

There are numerous difficulties in using the WTO Dispute Settlement process to challenge China's practices under MIC 2025. In its investigation of MIC 2025 as part of its Section 301 investigation of China's technology policies, USTR (2018) concluded that many Chinese practices -- such as forcing US companies to share intellectual property with a Chinese partner to obtain access to China's market -- do not violate China's WTO commitments. It makes no sense to bring a WTO case when there has been no WTO violation. Furthermore, the United States has already filed nearly two dozen cases against China at the WTO, with only limited effect, as recently described by USTR:

> Even though the United States has routinely prevailed in these WTO disputes, as have other WTO members in their disputes against China, they take years to litigate, consume significant resources, and often require further efforts when China resists complying with panel or Appellate Body rulings.

Under these circumstances, it seems unlikely that bringing litigation under the WTO will significantly change China's behavior, assuming the WTO is not reformed significantly. We believe it is certainly in the mutual interests of the US, Europe, Japan and Korea to reform the WTO.

<u>AD/CVD Litigation</u>

US industries that face unfair competition from China can use the AD/CVD laws to obtain relief, and many have already done so. AD/CVD relief can, and often does, result in tariffs that effectively preclude the dumped and/or subsidized imports from entering the US market. However, these laws are limited in their applicability and/or effectiveness:

- By definition, AD/CVD relief is available only when imports have caused or threatened material injury to a domestic industry, or caused material retardation of such an injury. In other words, obtaining relief generally requires domestic producers to suffer harm.
- Success in AD/CVD litigation requires the commitment of domestic producers that are willing to incur significant litigation costs to obtain relief. If there are no domestic producers or if domestic producers do not see a bright future for a particular industry, they are unlikely to pursue this type of litigation.
- AD/CVD relief is available only when the domestic industry can prove that the imports at issue have benefited from unfair trade. But over time, programs like MIC 2025 may allow China to build national champions that can dominate markets without the need for dumping or subsidies.
- Chinese programs like MIC 2025 may result in *global* excess capacity for a particular product. Under these circumstances, imposing tariffs on Chinese imports may simply divert those goods elsewhere -- leading to a surge of imports from a different group of countries.
- The AD/CVD laws are designed to impose relief on imports of a particular product from a particular country. But certain imports associated with the MIC 2025 program -- such as electric vehicles -- may consist of numerous different "products," and the supply chains for those products may run through multiple countries.

- The AD/CVD laws are designed to preserve a level playing field here in the United States. These laws generally will not help domestic producers grow sales in China and other non-US markets.

These limitations are apparent from Table 5, which shows US trade flows in industrial robots. The table shows that the United States, in recent years, runs an increasingly negative trade deficit in this advanced technology, suggesting a relatively weak domestic industry. Although China is the world's largest producer and consumer of industrial robots, it does not import a substantial amount to the United States. Chinese imports range from 1.9%-7% of total US imports, with the lowest percentages in the most recent years. In 2019, larger shares of US imports come from Japan (23%) and Germany (8.9%) than from China (1.9%). AD/CVD litigation is unlikely to successfully be brought against China.

Table 5. Annual US Trade Data for Industrial Robots ($ millions).

Statistic	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Exports (robots)	110.6	152.5	122.3	131.6	139.6	204.2	162.4	150.6
Imports (robots)	-195.5	-236.5	-202.7	-273.1	-285.1	-430.5	-481.6	-434.2
Exports (lifting)	86.6	110.9	95.6	103.9	115.0	61.8	63.6	56.2
Imports (lifting)	-324.0	-318.7	-434.3	-486.0	-513.4	-621.7	-543.1	-549.6
Exports (parts)	238.0	220.1	278.0	209.0	181.0	203.6	163.3	152.8
Imports (parts)	-192.7	-196.8	-178.4	-188.6	-231.1	-233.1	-263.1	-215.6
Exports (total)	435.2	483.4	496.0	444.5	435.5	469.5	389.4	359.6
Imports (total)	-712.2	-752.0	-815.5	-947.7	-1,029.6	-1,285.4	-1,287.8	-1,199.4
Trade Balance (total)	-277.0	-268.6	-319.5	-503.2	-594.0	-815.9	-898.5	-839.8

Source: US International Trade Commission. HTS commodity codes: industrial robots not otherwise classified (847950), industrial robots for lifting (8428900220), and industrial robot parts (8479909440).

<u>Section 201 (Safeguard Actions)</u>

Safeguard actions, pursuant to Section 201, may be imposed on imports from around the world. This fact means that safeguard actions may be able to address concerns about global excess capacity, or any situation where AD/CVD relief on a country will simply lead to a surge of imports from another country. But the injury standard for safeguard relief is even higher than the standard in AD/CVD litigation -- meaning that domestic producers are likely unable to access this relief without suffering significant harm. Furthermore, safeguard actions are meant to cover imports from around the world; relief generally cannot be targeted at a particular country, such as China. Safeguard actions are meant to be temporary measures, and to last only so long as necessary for domestic producers to adjust to new import competition. Such measures may not be suited to addressing the long-term challenge represented by MIC 2025. Finally, even if safeguard tariffs create a level playing field in the United States, such tariffs will not necessarily help US companies compete in China and other non-US markets.

Section 232 (national security actions)

The Trump Administration has shown great flexibility in using Section 232 to impose tariffs on a broad range of steel and aluminum imports. The Administration has also shown that Section 232 relief may be targeted -- both by granting exclusions for certain products not available in the United States, and by exempting certain countries (such as Canada and Mexico) from the effects of Section 232 relief. However, there are significant limitations regarding the use of Section 232. The statute provides authority to act only in situations only where the national security of the United States is at stake. Whether products like electric vehicles or robotics are critical to the national security of the United States is an open question: Is Section 232 even applicable? Furthermore, like many of the other laws available to US policymakers, Section 232 only allows for an adjustment of import levels. At most, therefore, it can serve as a shield to protect the US market – but not as a tool to open other markets or support domestic production over the long term.

Section 337

Section 337 allows US companies to obtain relief to block imports of goods that interfere with their intellectual property. China's MIC 2025 program involves numerous other forms of support that would not implicate Section 337. Furthermore, like the AD/CVD laws, this statute is designed for use by domestic producers seeking to address a very specific type of unfair trade -- not for policymakers seeking to respond to another country's industrial policy.

Section 301/Phase I Agreement with China

Section 301 is the broadest and most effective trade tool available for US policymakers, and the Trump Administration has shown that it can provide significant leverage over China. Between August 2017 and March 2018, USTR conducted a detailed investigation into China's unfair trading practices involving intellectual property. USTR then brought WTO litigation against practices it identified that appeared to violate WTO obligations, while the President imposed tariffs on Chinese goods in response to unfair practices that were not covered by China's WTO obligations. China responded with new tariffs on US goods, which led to a further response from the United States in the form of additional tariffs.

Eventually, both sides engaged in serious negotiations, which resulted in the Phase I agreement. This agreement involves a number of structural commitments by the Chinese government, leaves many US tariffs in place, and creates a potential for the United States to impose additional tariffs under Section 301 if China fails to comply.

Section 301 gives US policymakers the ability to pressure China with a broad range of tariffs, to use those tariffs as the basis for negotiations over structural issues (such as MIC 2025), and to enforce agreements resulting from those negotiations with the threat of potential tariffs. No other statute provides US policymakers so much leverage to address market-distorting programs China may adopt.

Nevertheless, Section 301 is subject to certain limitations:

- Section 301 gives US policymakers the ability to act unilaterally only in situations where China has not violated the WTO Agreements. Any unfair practices covered by China's WTO obligations would require use of the WTO's dispute settlement process.
- The leverage provided by Section 301 is limited by the extent to which China depends on access to the US market. As China becomes less dependent on the US market, the leverage provided by Section 301 will decline.
- China has shown that it can respond to Section 301 tariffs by imposing its own tariffs on US exports. Such tariffs can put political pressure on US policymakers from farmers and companies concerned about the potential loss of sales to China.

Like the other tools available to US policymakers, Section 301 operates by denying access to the US market. Such an approach can provide indirect support for domestic producers, by insulating them from competition with Chinese goods. But this type of support may not be sufficient to encourage the growth of robust American producers who can successfully compete in global markets against Chinese producers backed by MIC 2025.

Some of these trade policy tools involve tariffs on imports, which have a negative impact on US consumers, including manufacturers that rely on intermediate goods imported from abroad. Our argument here is that such trade tools are likely to be of limited applicability and effectiveness for reasons apart from tariff implications.

VIII. Implications for US Competitiveness

If currently available trade policy tools are not likely to be adequate to counter MIC 2025, what options are available to US policymakers? We consider four options: (1) develop new, improved domestic trade remedy tools, (2) employ policies apart from trade policy to thwart China's aims, (3) engage with allied nations to negotiate new trade rules and (4) develop a national competitiveness plan that more efficiently leverages American entrepreneurship and innovation.

First, US policy makers could develop a new, improved trade remedy tools. For example, the US process for proving dumping or anillegal subsidy could be made easier in terms of proof. It is, however, unlikely such new tools will pass muster with WTO obligations (e.g., WTO rules for AD and CVD). And even if it could, it is unlikely to be as robust as existing Section 301, which is already being used by the Trump Administration to impose tariffs on most Chinese imports. Thus far, use of Section 301 has proven inadequate to alter China's MIC 2025. Therefore, it is unlikely that new trade remedy tools can be developed to more effectively counter MIC 2025.

Second, US policymakers could utilize policy other than trade policy. An example would be scrutiny of Chinese investments in the United States through the Committee on Foreign Investment in the United States (CFIUS), to prevent China from investing in or purchasing a US firm that would impair US national security. Another example would be US export controls to prevent the export of strategic technologies from entering China. The United States is employing both. China, however, can sidestep US government intervention by shifting its focus to another country as a source of targeted technology. It is only when global market power is heavily concentrated in the United States might use of these policy tools be effective in hindering China's technology access.

Third, the US could build a multi-country coalition to reform and modernize the WTO. More narrowly, the US could engage, along with its allies, in the writing of new international trade rules to address historical issues (China was considered a developing nation when it joined the WTO in 2001 and its rules are less stringent than that of a developed nation) or issues unique to China (the behavior of internationaly powerful state-owned enterprises). A positive development is the ongoing trilateral dialogue between the United States, Japan, and the EU. The trade ministers recently issued a joint statement (US Trade Representative 2020a) acknowledging problems with the WTO ASCM (regarding subsidies) and forced technology transfer. These discussions are ongoing and may lead to allied efforts to address the more egregious of Chinese practices. However, this dialogue excludes China and China may choose to not comply.

More productive would be including China in developing new trade rules, such as the negotiations that the United States and China engaged in to achieve the Phase I agreement. Although it is too soon to assess success/failure, it seems clear that compliance is key: China has promised, and failed to deliver on, reform in the past (e.g., with respect to state-owned enterprises). Most recently, the Trump Administration admitted it is not pursuing trade talks with China towards a Phase II agreement (Breech and Lawder, 2020), though this may also reflect an unwillingness by China to engage in US discussions prior to the November 2020 election.

Finally, the US could shift from playing defense to playing offense by developing a national competitiveness plan. Such a plan could touch on a myriad of factors impacting the geographical location of production: workforce, finance, taxes, regulation, etc. Currently popular is discussion about "re-shoring" capabilities previously outsourced to China. In the interest of brevity, we focus here on research and development (R&D), which is critical to advanced technologies targeted in MIC 2025.

In the decades following WWII, significant and consistent R&D spending bolstered US manufacturing capabilities in such fields as biomanufacturing, materials science, aerospace, and information technology. Even today, the United States leads in several key R&D indicators: government R&D spending, total R&D spending (government and business), new science and engineering journal articles, and new science and engineering doctorates (Khan et al., 2020).

However, the rest of the world is catching up. China will soon surpass the United States in R&D spending, and 27 OECD nations exceed the United States in university R&D investment as a share of GDP (Atkinson & Foote, 2019). These dynamics reflect declining US government investment in R&D in the 21st century (Atkinson, 2020).

Atkinson (2020) and Shih (2020) recommend that the United States increase government investment in R&D to bring it on par with that of other advanced manufacturing economies. The form of this investment could be in platforms or mission-critical programs (e.g., the Human Genome Project).

The nature of innovation has evolved over several decades; breakthrough innovations at the frontiers of technology are increasingly associated with multi-disciplinary teams of researchers. And the resources needed to overcome the technological "valley of death" – the gap between basic R&D and commercialization—often discourage even the most well-funded firms. According to Mazzucato (2014), public funding is often necessary to "de-risk" private sector investment, as has been the US experience in smartphone technologies and breakthrough drugs: federal R&D investment has been critical to US success.

For these reasons, investment in pre-competitive collaborative research makes sense. Partners share resources on a technology platform that offers the opportunity for independently developed differentiated products in the future. Efficiency drives this model of research. Such collaboration can be just between private sector firms or across industry, government, and academia.

Other nations see value in pre-competitive collaborative research. Germany's famed Fraunhofer Institutes utilize this model. China does, too. As part of *Made in China 2025* program, China is developing 40 "manufacturing innovation centers."

Shih (2020) identifies potential projects suitable to pre-competitive consortia, including biomanufacturing and electric grid modernization. An existing example is the Manufacturing USA program, designed to speed the commercialization of advanced manufacturing technologies. Currently, there are 15 Manufacturing USA institutes, each focused on a particular platform technology (e.g., industrial robotics, lightweighting, bioprocessing). Ezell (2016) recommended expanding the number of Manufacturing USA institutes from 15 to 45 as originally envisoned.

As mentioned, a national competitveness plan could expand well beyond R&D. The ongoing global pandemic, and the related economic downturn, provide US policy makers the opportunity to revisit US dependence on China.
Of these four options, enhancing US competitiveness by investing in R&D seems most promising: It does not rely on China to change its policies or practices, and it would elevate US manufacturing relative to all competitor nations.

Arguably, the United States is currently pursuing an "all of the above" approach On "new rules," the Trump Administration has shied away from a multilateral process (believing these to be ineffective) in favor of forcing US rules on allies and others, what Kennedy (Kennedy 2019) has called "unilateral multilateralism." Presumptive Democratic candidate Joe Biden has criticized the Trump approach, arguing for greater emphasis on multilateral processes – and greater investment in US indigienous innovation (Biden, 2020).

IX. Conclusions

China is making progress in both electric vehicles and industrial robots, especially in serving its domestic market. Its progress in exports is less significant. MIC 2025 is enabling this progress, although there are signs of inefficiency, especially in terms of government subsidies. And it may be too early to tell if China will lead in pushing the technology frontier through a combination of indigenous innovation and scale of market.

MIC 2025 poses unique challenges to international trade rules and US trade policies, which are ill-suited to address a non-market economy of China's magnitude. In the short run, the United States will have to utilize its imperfect trade policy tools, while engaging with its allies and China in the development of new rules. And the US should consider developing an explicit manufacturing competitiveness plan to leverage its comparative advantage in innovation through greater investment in pre-commercial R&D. In the long run, the US should build an international coalition to reform the WTO.

X. Acknowledgments

The authors have beenfitted from conversations with the following individuals, who provided input and/or review of an early draft of this white paper: Gurminder Bedi, Gilbert Kaplan, Ryan Keefe, Scott Kennedy, Craig Seidelson, Saba Siddiki, Terry Straub, and Stephen Vaughn. Any errors of omission or commission that remain are solely the responsibility of the authors.

The views and opinions in this white paper are those of the authors and do not represent the position of Indiana University, the O'Neill School of Public and Environmental Affairs, nor the Manufacturing Policy Initiative.

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Appendix: List of Specific Policies of China for Industrial Robots

NATIONAL LEVEL

Date	Title of Policy	Agency	Description
February 7th, 2006	Medium-and Long-Term Science and Technology Development Plan (2016-2020) / 《国家中长期科学和技术发展规划纲要》(2006-2020)	State Council	This plan determined that by 2020, the nation-wide investments in R&D shall increase to more than 2.5% of the total GDP, and that the scientific and technological progress contribution rate shall rise above 60%, and that China's reliance on foreign technology to be reduced from 50 percent to 30 percent. In addition, the annual authorization of national invention patents and citations of international scientific papers shall be ranked among the top 5 in the world.
August 23rd, 2013	Notice on Informatization and Industrialization Deepening Integration Special Action Plan (2013-2018) / 《信息化和工业化深度融合专项行动计划》 (2013-2018年)	MIIT	According to the action plan, eight major actions will be carried out to promote the in-depth integration of informatization and industrialization.
May 19th, 2015	<Made in China 2025> / 《中国制造2025》	State Council	This ten-year strategy aimed to upgrade and accelerate the nation's technological development, boost productivity, and make innovation a driver of economic growth. Established nine priority tasks and ten key sectors to promote breakthroughs. High-end numerical control machinery and robots are two of the areas that the nation is planning to focus on.
July 1st, 2015	Guiding Opinions of the State Council on Promoting the Internet Plus Action Plan / 《国务院关于积极推进"互联网+"行动的指导意见》	State Council	The action plan calls for "deep and comprehensive integration between the Internet and the real economy". More summaries available through USITO's report.
July 10th, 2015	Opinion of MIIT on Promoting the Development of Industry Clusters /	MITT	According to the guidelines, industrial clusters should establish collaborative innovation

	《工业和信息化部关于进一步促进产业集群发展的指导意见》		networks with universities and research institutions, establish industrial cluster R&D centers, design centers, and engineering technology centers, and build collaborative R&D platforms for industries and products. Moreover, the guidelines encourage enterprises to form industrial alliances or R&D alliances and strengthen the integration of industrial chains and supply chain management.
September 29th, 2015	Made in China 2025: Major Area Key Technology Roadmap / 《中国制造 2025 重点领域技术路线图》	National Manufacturing Power Strategic Advisory Committee	This announcement set specific sales growth and market share targets for a variety of industries and domestic productions.
December 30th, 2015	Guideline for Establishing the National Smart Manufacturing Standards System (2015 edition) / 《国家智能制造标准体系建设指南》	MITT and SAC	As a general principle, the guideline calls for strengthening the formation and industrialization of standards with indigenous IP and elevating indigenous IP standards into international standards.
February 16th, 2016	Several Opinions on Finance to Support Industry Stable Growth, Restructuring, and Improving Profit / 《关于金融支持工业稳增长调结构增效益的若干意见》	PBOC, NDRC, MIIT, MOF, MOFCOM, CBRC, CIRC, CRSC	To strengthen monetary and credit policy support, create a sound monetary and financial environment, increase support from the capital and insurance markets for industrial enterprises, promote innovation in financing mechanisms for industrial enterprises, and promote mergers and reorganizations of industrial enterprises.

March 17th, 2016	The 13th Five-Year Plan / 《中华人民共和国国民经济和社会发展第十三个五年规划纲要》	State Council	This plan emphasized indigenous innovation, signaling the importance of achieving technology self-sufficiency, as it reflects the enduring role that such advancement has in the market.
March 21st, 2016	Robotic Industry Development Plan (2016-2020) /《机器人产业发展规划》(2016-2020 年)	NDRC, MIIT	By 2020, the annual outputs for self-owned/independent brand produced industrial robots should reach 100,000 units and the annual sales for service robots should exceed 30 billion yuan. In five years, China shall form its own relatively complete robot industrial system. The next phase of related incentive policy will begin to address two critical issues: one is to promote the development of the robot industry toward the middle to eventually high-end market; the second, is to standardize the market regulations and prevent the robot industry to develop in a disorderly manner.
April 11th, 2016	Notice on Launching Smart Manufacturing Pilot Demonstration 2016 Special Action / 《关于开展智能制造试点示范 2016 专项行动的通知》	MITT	This action plan called to fully launch the intelligent transformation of traditional manufacturing industries. Through pilot demonstrations, the plan shall promote and upgrade five key technologies: high-end CNC machine tools, and industrial robots, additive manufacturing equipment, intelligent sensing and control equipment, intelligent detection and assembly equipment, and intelligent logistics and storage equipment.
May 13th, 2016	Guiding Opinion on Development of Manufacturing and Internet Integration / 《国务院关于深化制造业与互联网融合发展的指导意见》	State Council	By the end of 2018, the penetration rate of Internet "mass entrepreneurship and innovation" platforms for

			backbone enterprises in key manufacturing industries shall reach 80 percent. Compared with the end of 2015, the number of users of industrial cloud enterprises will double, the R&D cycle of new products shall be shortened by 12 percent, the inventory turnover rate will increase by 25 percent, and energy efficiency shall increase by 5 percent. By 2025, the plan strives to achieve a substantial increase in the overall competitive strength of the manufacturing sector.
August 1st, 2016	Plan to Enhance Standardization and Quality of Equipment Manufacturing / 《装备制造业标准化和质量提升规划》	AQSIQ, SAC, and MITT	By 2020, the standard system of intelligent manufacturing and green manufacturing shall be improved, the pace of meeting international standards on quality and safety shall be accelerated, and the quality level of key equipment shall reach or approach the advanced international level. By 2025, the standard system of equipment manufacturing industries and service industries should be aligned with the MIC 2025 goals.
August 8th, 2016	13th Five-Year Plan on Science and Technology Innovation Plan / 《"十三五"科技创新规划》	Ministry of Science and Technology of the People's Republic of China	This plan proposed to accelerate the implementation of major national science and technology projects, launch the "science and technology innovation 2030 -- major projects", strengthen the integration of modern agriculture, the new generation of information technology, intelligent manufacturing, energy as well as other fields. This plan aimed to promote disruptive technological innovation and accelerate industrial transformation.
September 19th, 2016	Notice on 2016-2018 Special Action Smart Hardware Industry Innovative	MITT and NDRC	The special action strived to solve the problems of insufficient

	Development /《智能硬件产业创新发展专项行动》(2016-2018 年)		supply of key technologies and high-end products, imperfect innovation support systems, and promote the high-end, innovative, and service-oriented development of China's intelligent hardware industry.
October 12th, 2016	Informatization and Industrialization Development Plan (2016-2020) / 《工业和信息化部关于印发信息化和工业化融合发展规划》（2016-2020 年）	MITT	To stimulate the innovation vitality and development potential of the manufacturing industry, this plan sets up seven major tasks, six key projects, and five safeguard measures.
October 21st, 2016	Industrial Technology Innovation Capabilities Development Plan (2016-2020) / 《产业技术创新能力发展规划》（2016-2020）	MITT	This plan proposed an industrial technology innovation system with enterprises as the main body, the market as the guide, and the combination of government, industry, education, research, and application to accelerate the transformation of scientific and technological achievements into real productive forces.
November 29th, 2016	13th Five-Year Plan on Strategic and Emerging Industries / 《"十三五"国家战略性新兴产业发展规划》	State Council	By 2020, the added value of strategic emerging industries shall account for 15% of the GDP. This strategy shall form five new pillars with an output value of 10 trillion yuan, namely, the new generation of information technology, high-end manufacturing, biology, green and low-carbon technologies, and digital creativity. Moreover, the plan anticipated to create cross-border integration in a wider range of fields, and generate more than one million new jobs on average each year.
December 8th, 2016	Smart Manufacturing Development Plan (2016-2020) /《智能制造发展规划》（2016-2020）	MIIT, MOF	This plan called for digital manufacturing to be basically realized in key areas of traditional manufacturing by 2020. The plan aimed to establish a support system for intelligent

			manufacturing, and key industries shall complete the initial stage of intelligent transformation by 2025.
December 27th, 2016	13th Five Year Plan on National Informatization Plan / 《"十三五"国家信息化规划》	State Council	This plan called for achieving systematic breakthroughs in indigenously innovated core technology, raising the indigenous innovation capability for cloud computing, and fundamentally establishing a secure and controllable information industry ecosystem by 2020.
December 29th, 2016	Standard Conditions for Robot Industry /《工业机器人行业规范条件》	MIIT	Following the principles of encouraging technological progress, standardizing competitive behavior, and promoting safe production, this plan set out requirements for enterprises in six areas: enterprise-scale, quality requirements, R&D and innovation capability, talent strength, sales, and after-sales service, and social responsibility.
December 29th, 2016	Notice on promoting the healthy and sustainable development of the robot industry /《关于促进机器人产业健康发展通知》	MITT, NDRC, CNCA	This notice published suggestions to expand the application market for industrial robots, to foster leading enterprises, to concentrate the limited resources to tackle shortcomings, to protect enterprises' enthusiasm in research and development, and to improve their capacity for sustainable development.
August, 2017	Guidelines for key intelligent robot projects in 2017 /《"智能机器人"重点专项 2017 年度项目专项申报指南》	Ministry of Science and Technology of the People's Republic of China	With a budget of about 600 million yuan, 42 projects have been launched in six directions: basic frontier technology, generic technology, and cutting-edge technologies for industrial robots, next-generation robots, service robots, and special robots.

August 21st, 2017	Measures for the standardized management and implementation of industrial robot industry /《工业机器人行业规范管理实施办法》	MIIT	This announcement clarified the division of responsibilities of related units.
November 11th, 2017	High-end Smart Manufacturing Action Plan (2018-2020) / 《高端智能再制造行动计划》（2018 – 2020 年）	MIIT	This plan strived to accelerate the development of China's high-end smart remanufacturing industry, and promote sustainable development and growth.
November 20th, 2017	Guiding Opinions on Incorporating Private Investment and Implementing Strategy to make China a Manufacturing Powerhouse /《关于发挥民间投资作用，推进实施制造强国战略的指导意见》	MITT, NDRC, MOST, MOF, MEP, MOFCOM, PBOC, SAIC, AQSIQ, CNIPA, CAE, CBRC, CSRC, CIRC, SASTIND, ACFIC	The guiding opinions aimed to encourage and support private enterprises to participate in the research and development of key technology and manufacturing high-grade CNC machine tools, industrial robots, as well as specialized additive manufacturing equipment, testing equipment, and production equipment that are needed by the top ten areas outlined in MIC 2025. Thus, this policy proposal hopes to further cultivate and improve these intelligent manufacturers' ability to provide system integration and service.
December 14th, 2017	Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018-2020) /《促进新一代人工智能产业发展三年行动计划(2018-2020 年)》	MIIT	By 2020, the action plan strives to further enhance the intelligence level of high-end CNC machine tools and industrial robots.

PROVINCIAL LEVEL

Date	Title of Policy	Agency	Description
April 22nd, 2017	Anhui's supportive policies for the construction of manufacturing strong provinces (2017) /安徽支持制造强省建设若干政策	The People's Government of Anhui Province	Provincial-level of policy directions on how to carry out the five development action plans, thoroughly implement "Made in China 2025 – Anhui edition", and promote the province's manufacturing industry, and how to better support high-end manufacturing, intelligent manufacturing, high-quality manufacturing, green manufacturing, service-oriented manufacturing, electronic information, software, and big data industries, and ultimately support enterprises to become bigger and stronger.
July 2nd, 2018	Supportive policies for robot industry in Anhui Province (2018) /安徽省支持机器人产业发展若干政策(2018)	The people's Government of Anhui Province	Encourage enterprises that specialized in robotic manipulators and key components to becoming stronger. For robotic manipulators enterprises that have invested over 10 million yuan or more in its new or under construction projects, they can receive a one-time subsidy of up to 5 million yuan. For enterprises that specialized in manufacturing the five major components, a one-time subsidy of up to 5 million yuan will be given according to the purchase amount of key equipment in new or ongoing projects.
July 5th, 2018	Development plan of robot industry in Anhui Province (2018-2027) / 安徽省机器人产业发展规划(2018—2027年)	The people's Government of Anhui Province	If an enterprise purchases industrial robots, it can enjoy up to 1 million yuan of awards and subsidies according to a certain proportion of the purchase amount. Support the establishment of a robot industry innovation service platform, and grant the organization a one-time subsidy that is up to 3 million yuan. This award is based on the amount of investment that the

			organization has spent on key equipment.
July 14th, 2015	Nine measures people's government of Fujian province to accelerate the development of intelligent manufacturing (2015)/福建省人民政府关于加快发展智能制造九条措施	General Office of People's Government of Fujian Province	By 2020, the output value of the intelligent equipment manufacturing industry and the business income of the industrial software industry shall both exceed 100 billion yuan. Plan to form 20 backbone intelligent equipment enterprises and several key industrial software enterprises. By 2020, more than 10,000 machines (sets) will be replaced, 70% of production equipment in key fields will be CNC, and 20 intelligent manufacturing model factories (workshops) will be built.
March 13th, 2018	Implementation opinions on accelerating the development of the new generation of artificial intelligence in Fujian Province (2018) / 福建省关于新一代人工智能加快发展的实施意见(2018)	General Office of People's Government of Fujian Province	Focus on the research and development of controller, servo motors, reducer, and other high-performance robot core components.
December 3rd, 2015	Special Action Plan for Robot Industry in Guangdong（2015) / 广东省机器人产业发展专项行动计划(2015)	General Office of People's Government of Guangdong Province	The province will cultivate and develop enterprises that specialized in industrial robot system integration as well as the research and development in robot manufacturing. The province will strive to make breakthroughs in the core technologies of the off-line programming system, control, and servo drive technology for robot，sensing technology, reliability, and integration technology. By doing so, the province hopes to provide the necessary technical support that is needed for the robot industry.
February 13th, 2017	The 13th five-year plan for the development of key advanced manufacturing industries in Guangdong province/广东省先进制造业重点产业发展"十三五"规划	General Office of People's Government of	Plans to boost manufacturing innovation center construction, promote the scientific and technological achievements in manufacturing, strengthen the protection of intellectual property

		Guangdong Province	rights and use, speed up the development of intelligent manufacturing such as the industrial robot and focus on the technological upgrading, equipment upgrading, information technology upgrading in the existing industries.
March 1st, 2017	Premium Subsidy Pilot Program for Guangdong Province's Industrial Robot Sector (2017) /广东省工业机器人保费补贴试点工作方案(2017)	Industry and information Technology Department of Guangdong Province	Under the guidance of the government and the principle of market operation, a provincial-level industrial robot insurance subsidy mechanism shall be established, and insurance companies shall provide customized comprehensive insurance products for the special risks of industrial robot application, and encourage industrial robot manufacturers to actively insure. The provincial financial fund will provide premium subsidies, share risks for production enterprises and users, accelerate the promotion and application of industrial robots independently developed in Guangdong, improve the competitiveness of the product market, and accelerate the development of the industrial robot industry in Guangdong.
December 14th, 2017	Action plan for advanced equipment manufacturing industry in the pearl delta region (2018-2020) / 珠江西岸先进装备制造产业带聚焦攻坚行动计划(2018-2020 年)	General Office of People's Government of Guangdong Province	When a product meets the MITT's catalog requirements, its manufacturer will earn a reward from the government for each unit sold. This prize is approximately 30% of the product's retail value.
January 10th, 2018	3-year action plan for technological transformation of industrial enterprises in Guangdong province (2018-2020) /广东省工业企业技术改造三年行动计划（2018-2020）	General Office of People's Government of Guangdong Province	From 2018 to 2020, more than 25,000 industrial enterprises will carry out the technological transformation, with an average annual increase of more than 20% in investment, and a total investment of more than 2 trillion yuan. Plan to promote intelligent advancement and equipment upgrade, increase support for the first unit (set) of major technical

			equipment, and strengthen financial guidance and support for the industrial enterprises.
August 14th, 2018	Development Plan for New Generation of Artificial Intelligence in Guangdong Province (2018) / 广东省新一代人工智能发展规划(2018)	General Office of People's Government of Guangdong Province	The province will promote the development, industrialization, and optimization of robots and their components. Furthermore, the province will continue to promote the demonstration of integrated robot applications in sectors such as automobiles, petrochemicals, machinery manufacturing, and the production and packing of dangerous goods.
August 31st, 2017	The 13th five-year plan for industrial transformation and upgrading in Hebei Province (2016) / 河北省工业转型升级"十三五"规划	Hebei Province's Department of Industry and Information Technology	The province will strengthen policy support, optimize the allocation of innovative resources, improve the supporting industrial system, encourage the development of angel funds, venture capital, and other equity investment funds, and provide diversified support for the development of strategic emerging industries.
July 24th, 2018	Action plan for accelerating the development of intelligent manufacturing in Hebei Province (2018-2020) / 河北省加快智能制造发展行动方案(2018—2020年)	General Office of People's Government of Hebei Province	By 2020, a relatively complete intelligent manufacturing industry system will be formed in the whole province, and the level of intelligent manufacturing and the application rate of intelligent equipment will be significantly improved. The saturation rate of digital R&D plus design tools for enterprises in key manufacturing areas should rise to 65%, and the key numerical control operation rate should rise to 52%. The business revenue for the intelligent equipment industry should reach 100 billion yuan.
March 10th, 2019	Suggestions on supporting the development and application of robot industry in Hebei Province (2019) / 河北省支持机器人产业发展和应用的若干意见(2019)	General Office of People's Government of Hebei Province	The province will support the development of welding, cutting, spraying, and other industrial robots. In terms of technological transformation and upgrading of enterprises, the subsidy amount can reach 10 million yuan.

January 30th, 2015	Implementation opinions of Henan Province's effort to promote the development of the industrial robot industry (2015) / 河南省推进工业机器人产业发展的实施意见(2015)	General Office of People's Government of Henan Province	By 2020, the province will form a 100 billion yuan worth of industrial clusters, focusing on the intelligent equipment manufacturing as well as industrial robots. By 2020, the annual output of industrial robots should reach 100,000 units, and the province should establish 3 industrial parks for industrial robots.
December 11th, 2015	Opinions of Henan provincial people's government on supporting the construction of robot and intelligent equipment industrial base in Luoyang /河南省人民政府关于支持洛阳市建设机器人及智能装备产业基地的意见	General Office of People's Government of Henan Province	Promote the centralized distribution of projects, improve the industrial supporting system, and form an industrial pattern dominated by "one base and two parks". Foster and expand the Luoyang's robot and intelligent equipment industrial base, and accelerate the construction of a major province with advanced manufacturing industries.
August 14th, 2018	Measures to promote the transformation and development of the logistics industry in Henan Province (2018) / 河南省促进物流业转型发展若干措施 (2018)	Henan Province Commerce Department	For enterprises that purchase advanced equipment such as delivery drones, intelligent logistics vehicles, sorting robots, and so on, a financial subsidy will be provided. Should this investment exceed 3 million yuan, the subsidy shall be no more than 30% of the investment or no more than 3 million yuan.
April 18th, 2019	Policies to support the development of intelligent manufacturing and industrial Internet in Henan Province / 河南省支持智能制造和工业互联网发展若干政策	General Office of People's Government of Henan Province	In terms of the development of intelligent equipment industry, projects with a major driving force and investment of more than 300 million yuan will be given priority to be included in the management scope of key projects in Henan province, and funds such as the special fund for the development of advanced manufacturing industry in Henan province will be supported. For the key intelligent equipment industrial base listed in the three-year action plan for intelligent manufacturing and industrial

			Internet development of Henan province, the local government shall issue corresponding supporting policies. In terms of the intelligent transformation of enterprises, relevant policies shall be formulated at the provincial level for the implementation of "machine replacement", the intelligent transformation of production lines, the construction of intelligent workshops, intelligent factories, and intelligent demonstration parks.
July 11th, 2014	Implementation opinion on promoting industry development for the industrial robot in Hubei Province (2014) / 湖北省推动工业机器人产业发展的实施意见 (2014)	Industry and information Technology Department of Hubei Province	By 2020, the province will form a relatively complete industry system for industrial robots, and its main business income shall reach 10 billion yuan. Cultivate 1 to 2 leading industrial robot enterprises with independent intellectual property rights and brands, 5 to 10 supporting enterprises that are specialized in producing key components, and build 1 to 2 industrial clusters for industrial robots.
January 26th, 2017	13 Five-Year Development Plan for Hubei Province's intelligent equipment manufactures (2017) / 湖北省智能制造装备"十三五" 发展规划	General Office of People's Government of Hubei Province	The province's ability for innovation and its industrial robot technology's market competitiveness should be significantly enhanced. The rate that manufacturing enterprises utilize industrial robots in the region shall surpass more than 50%. The province should aim to become a core demonstration area for the production, integration, and service of industrial robots in central China, and one of the important industrial bases for industrial robots in China.
June 8th, 2015	To better implement the MIC 2025's initiatives – Hunan Province's five-year action plan for building and construing a strong manufacturing province (2016-2020) / 湖南省贯彻<	General Office of People's Government	The province will vigorously promote intelligent manufacturing, focusing on the new generation of information technology industry, high-grade CNC machine

	中国制造 2025>建设制造强省五年行动计划(2016—2020 年)	of Hunan Province	tools, robots, and advanced rail transit equipment, construction machinery, and other key areas. The province strives to make breakthroughs in the province's key areas of intelligent manufacturing and accelerate the development of intelligent manufacturing.
March 1st, 2019	Three-year Action Plan for The Development of The Artificial Intelligence Industry in Hunan Province (2019-2021) / 湖南省人工智能产业发展三年行动计划 (2019—2021 年)	Industry and information Technology Department of Hunan Province	The province will promote the application of industrial robots in advantageous sectors as construction machinery, automobiles, new materials, nonferrous metallurgy, electronic information, aerospace, food and medicine, civil explosion, and fireworks.
May 18th, 2018	Opinions regarding the implementation of Jiangsu Province's effort to promote the generation of artificial intelligence's development (2018-2020) /江苏省新一代人工智能产业发展实施意见 (2018—2020 年)	Jiangsu Province's Development and Reform Commission	Accelerate the development of artificial intelligence software and hardware industry. The action plan requires that the performance, accuracy, and reliability of precision reducers, servo motors, drivers, and controllers used for robots shall reach the international level of similar products. The density of robots in key industries (number of robots used per 10,000 employees) shall exceed 200.
December 6th, 2018	Three-year action plan for the development of the robot industry in Jiangsu Province (2018-2020) / 江苏省机器人产业发展三年行动计划 (2018—2020 年)	Jiangsu Province's Ministry of Industry and Information Technology	The goal is that the output value of the robot industry in the whole province will reach 100 billion yuan within three years, along with an annual growth rate of more than 35%. The annual output of industrial robots from autonomous brands will reach 10,000, and many key leading enterprises, well-known brands, and featured industrial bases will be formed.

August 6th, 2016	Shandong Provincial People's Government's Policy measures to promote the development of capital market and the transformation and upgrading of key industries / 山东省推动资本市场发展和重点产业转型升级财政政策措施	General Office of People's Government of Shandong Province	Plan to increase support for the development of emerging industries, conscientiously implement fiscal and taxation preferential policies to support the development of the transformation and upgrading of industries and emerging industries, and further support enterprises to carry out the "machine substitution" movement and improve the insurance compensation policy for the first unit (set) of major technical equipment and key core components.
August 7th, 2017	Development Plan of Intelligent Manufacturing in Shandong Province (2017-2022) / 山东省智能制造发展规划(2017—2022年)	Industry and information Technology Department of Shandong Province	By 2022, the penetration rate of digital R&D and design tools for enterprises in traditional industries in the province will reach more than 72%, the rate of numerical control of key processes in industrial enterprises above the scale shall reach more than 57%, and the number of robots for 10,000 people will reach more than 200. Before and after the implementation of the pilot demonstration project of intelligent manufacturing, the operating cost of the enterprise should be reduced by 20%, the product development cycle should shorten by 20%, the production efficiency should increase by 20%, the energy efficiency should increase by 13%, and the defective product rate should be greatly reduced.
June 23rd, 2015	Opinions of Zhejiang provincial people's government on further promoting the steady and innovative development of provincial economy (2015) / 浙江省人民政府关于进一步促进全省经济平稳发展创新发展的若干意见	General Office of People's Government of Zhejiang Province	Plan to intensify technological upgrading of enterprises, promote the "replacement of machines", and encourage enterprises to purchase industrial robots and intelligent manufacturing systems in technological upgrading.
June 7th, 2017	Action plan for comprehensive transformation and upgrading of		Plan to vigorously promote technological innovation in

	traditional manufacturing industry in Zhejiang province (2017-2020) /浙江省全面改造提升传统制造业行动计划（2017—2020 年）		enterprises, strive to implement 100 technology renovation projects with a total investment of more than 1 billion yuan in key traditional manufacturing industries by 2020, increase the number of industrial robots by 20,000 and create 25 provincial-level "machine replacement" engineering and technical service companies.
February 6th, 2018	Action plan for intelligent manufacturing in Zhejiang Province (2018-2020) / 浙江省智能制造行动计划(2018—2020 年)	General Office of People's Government of Zhejiang Province	For those that have purchased industrial robots, the local government will cover 10% of the cost for said units.
February 12th, 2018	"Robot +" Action Plan for Zhejiang Province (2018-2020) / 浙江省"机器人+"行动计划》(2018—2020 年)	General Office of People's Government of Zhejiang Province	Companies that have ordered industrial robots or participated in the movement of replacing workers with machines, a financial subsidy will be provided.
May 7th, 2018	Action plan for accelerating the transformation and upgrading of traditional manufacturing industries in Zhejiang province (2018-2022) / 浙江省加快传统制造业改造提升行动计划(2018-2022 年)	General Office of People's Government of Zhejiang Province	Strive to make the traditional manufacturing industry significantly improve its position in the national and international division of industrial division and value chain through five years of efforts, and to become a demonstration zone for the transformation and upgrading of the traditional manufacturing industry. Plan to vigorously promote the transformation of intelligent technologies and hope that by 2022, the traditional manufacturing industry will have implemented 200 technology renovation projects with a total investment of more than 1 billion yuan, 30,000 new industrial robots, and 50 provincial-level industrial information engineering companies.

MUNICIPAL LEVEL

Date	Title of Policy	Agency	Description
September 26th, 2014	Three-year Action Plan for the Industrial Robot Sector (2015-2017) /长沙市工业机器人产业发展三年行动计划(2015-2017 年)	Changsha's Ministry of Industry and Information Technology	The city will vigorously attract investment and cultivate local enterprises, accelerate the introduction of core technologies and key talents, and comprehensively enhance Changsha's industrial competitiveness. To achieve scale application for the industrial robot in the city's key industrial areas, and increase the industrial robot density up to 100 units per ten thousand workers. Through technology introduction and independent development, accelerate the breakthrough in the design and processing technology of robot manipulators and core parts, and promote the industrialization of the industrial robot. Encourage traditional equipment manufacturing and labor-intensive enterprises to make use of industrial robots and intelligent technologies, and carry out intelligent upgrading and transformation in combination with their technological equipment. Centering around users' demands from key industrial manufacturing areas, the city will carry out the task to implement system integration for industrial robots and intelligent equipment. Similarly, the city will also design, manufacture, test, and research the core components for industrial robot and intelligent equipment, such as precision gear reducers, servo drives, sensors, etc. to provide effective support for the healthy and sustainable development of industrial robot sector.

July 29th, 2015	Three-year action plan for intelligent manufacturing in Changsha / 长沙智能制造三年(2015—2018 年)行动计划	General Office of Changsha People's Government	A few enterprises and projects will be introduced and cultivated to promote the transformation and upgrading of many traditional enterprises, pilot manufacturing demonstration represented by digital workshop/intelligent factory will be carried out, and a new promotion mechanism will be established to support the development of intelligent manufacturing.
August 4th, 2014	Implementation opinions on accelerating the development of industrial robot intelligent equipment industry in Dongguan / 东莞《关於加快推动工业机器人智能装备产业发展的实施意见》（2014）	People's Government of Dongguan	In order to implement the guidance of the ministry of industry and information technology on promoting the development of industrial robot industry, accelerate the development of intelligent industrial robot equipment industry in our city, promote the application of intelligent industrial robot equipment, promote the development of advanced manufacturing industry and the real economy, and promote the adjustment, transformation, and upgrading of industrial structure, this implementation advice is thus formulated to support these goals.
August 4th, 2014	Dongguan's "machine replacement" action plan 东莞推进企业"机器换人"行动计划（2014—2016 年）	General Office at the People's Government of Dongguan	By 2016, Dongguan will strive to complete the application project of "machine replacement" in relevant traditional industries and competitive industries, and promote more than half of the industrial enterprises above the scale in Dongguan to implement technical transformation projects. Dongguan will set up a special fund for "machine replacement" to promote the implementation of the application project. Enterprises that purchase "machine replacement" equipment and technology through their own funds, bank loans, equipment leasing, etc., will be given after-the-fact rewards or discount interest support according to a certain proportion of the investment.
July 12th, 2019	Policies and measures to support the development of the new generation of artificial intelligence industry in Dongguan (2018) /东莞市	Dongguan Development and Reform Bureau	By way of equity investment, the government will support the innovation projects committed to building and implementing new technologies that cost 50 million yuan or more.

	支持新一代人工智能产业发展的若干政策措施(2018)		
July 19th, 2018	Development plan of key emerging industries in Dongguan (2018-2025) /东莞市重点新兴产业发展规划(2018-2025 年)	Dongguan Development and Reform Bureau	For innovation programs that are committed to building and implementing new technologies but cost 10 million yuan or more, the government will provide subsidies in stages, ranging from 5% to 10% of the total amount that was invested by the companies. For innovation programs that are committed to building and implementing new technologies but cost 10 million yuan or more, the government will also provide loans with discounted interest rates, but they shall not exceed 70% of the total fixed assets formed upon the completion of these projects.
April 16th, 2018	Support program to promote the application and industrial development of robot in Foshan (2018-2020) /佛山推动机器人应用及产业发展扶持方案(2018-2020 年)	General Office of Foshan People's Government	According to Foshan's three-year plan to promoting the robotic application and industrial development, the municipal government has set up a special fund of 130 million yuan per year.
December 20th, 2018	Songshan lake high-tech zone's interim measures of to promote the development of robot and intelligent equipment industry /松山湖促进机器人与智能装备产业发展暂行办法(2018)	Science and technology innovation bureau of Songshan lake industrial park	Support innovation, as well as focus on supporting enterprises with independent intellectual property rights, cultivate leading enterprises and promote subsidies. The policy hopes to encourage enterprises to continue to innovate through incentives, constantly raise the technological threshold of enterprises themselves and to produce more first unit (set) of intelligent equipment from Songshan lake industrial park.
May 10th, 2018	Implementation measures for promoting the development of the robot industry in Foshan's Shunde district (2018) / 佛山市顺德区促进机器人产业发展实施办法(2018)	Foshan/Shunde's Economic and Technological Promotion Agency	According to the implementation measures for promoting the development of the robotics industry in the Shunde district, each qualified robotic enterprise can receive subsidies for up to 20 million yuan per year, and each (backbone) enterprise can enjoy the subsidy for no more than three years in total.
April 3rd, 2014	Implementation opinions on Guangzhou's municipal government's effort to promote the developmen	General Affairs Office of Guangzhou Municipal	By 2020, a 100 billion yuan worth, industrial robot-centered intelligent equipment industrial cluster will be formed. This industrial cluster shall have the

	t of industrial robot and intelligent equipment industry (2014) /广州市人民政府办公厅关于推动工业机器人及智能装备产业发展的实施意见(2014)	People's Government	capacity of producing 100,000 sets of industrial robots and intelligent equipment annually. By 2020, the city will cultivate 1 to 2 leading industrial robot enterprises with independent intellectual property rights and 10 billion yuan brands, as well as 5 to 10 supporting backbone enterprises. By 2020, the city will build 2-3 industrial robot industrial parks, and more than 80% of the manufacturing enterprises in the city should utilize industrial robots and intelligent equipment.
October 13th, 2013	Three-year Action Plan to Promote the "Machine Replacement" Technology Transformation in Jiaxing (2013-2015) /嘉兴市推进企业"机器换人"技术改造三年行动计划(2013-2015 年)	General Office of Jiaxing People's Government	Within three years, Jiaxing plans to conduct "machine substitution" in all industrial enterprises that comply with the regulations, carry out 1,000 technical renovation projects, complete 80 billion yuan of investment, and reduce about 200,000 employees in total.
January 22nd, 2016	嘉兴市加快推进智能制造发展三年行动方案(2016-2018 年)	General Office of Jiaxing People's Government	By 2018, the output value of intelligent manufacturing equipment shall exceed 26 billion yuan, and more than 100 enterprises will be cultivated. This plan strives to organize and implement 900 demonstration projects of intelligent transformation. The coverage of "machine replacement" in industrial enterprises shall reach 90%, the density of robots used in manufacturing should be over 150 units (sets) per 10,000 workers and the average annual increase in the productivity of all employees in industrial shall be more than 10%. The penetration rate of enterprises' digital R&D and design tools shall exceed 73%, the CNC rate of key enterprises' equipment shall exceed 48%, and the network connection rate between machines and equipment shall exceed 33%.
May 18th, 2017	Jiaxing municipality's three-year action plan of "robot +" / 嘉兴市"机器人＋"三年行动方案(2017～2019 年)	General Office of Jiaxing People's Government	In the three years from 2017 to 2019, this plan strives to achieve the goal of "robot +" and "123", that is, 10,000 industrial robots will be in service, 200 billion yuan will be invested in the technological transformation of "machine replacement", and 300

			intelligent manufacturing projects will be constructed.
April 16th, 2019	Subsidy operation rules for Jiaxing municipal industrial and information development fund / 嘉兴市级工业和信息化发展资金补助操作细则(2019)	Jiaxing municipal industrial and information development fund management committee office	These rules are formulated to promoting the construction of advanced manufacturing cities and digital economy cities, supporting and guiding the transformation and upgrading of industrial economies at the municipal level, and to better utilize financial assistance.
April 18th, 2019	Jiaxing municipality's three year action plan to further promote and implement the intelligent technology transformation for industrial enterprise / 嘉兴市深入推进工业企业智能化技术改造三年行动计划(2019～2021 年)	General Office of Jiaxing People's Government	From 2019 to 2021, the city should make a total investment of 100 billion yuan in intelligent technology renovation, accounting for 70% of the total investment. The number of industrial robots in service in the city should reach more than 18,000, and the density of industrial robots in the designated manufacturing enterprises should reach more than 2 sets per 10,000 persons; The numerical control rate of equipment in key enterprises of the industry should reach above 70%, and the network coverage rate of digital equipment in key enterprises of the industry should reach above 55%. More than 100 smart factories (digital workshop) demonstrations should also be provided.
January 8th, 2015	Development plan of robot, wearable device and intelligent equipment industry in Shenzhen (2014-2020) / 深圳市机器人、可穿戴设备和智能装备产业发展规划 (2014-2020 年)	Commerce Bureau of Shenzhen Municipality	For municipal level engineering laboratories, key laboratories, engineering (technology) research centers, and enterprise technology centers that are set up in Shenzhen and meet the prescribed conditions, the city will provide up to 500 million yuan in support of their operations. For enterprises, colleges, universities, and research institutions that undertake the tasks of constructing national engineering labs, key national laboratories, and national engineering centers in Shenzhen, the city shall give them up to 15 million yuan in support of their operations.
April 25th, 2019	Shenzhen municipal bureau of industry and information technology's operational procedures for the special fund support	Shenzhen's bureau of industry and information technology	To better regulate and improve the efficient use of the municipal department of industry and information technology's special fund for emerging industry's strategic development (hereinafter referred to as

	plan for the development of strategic emerging industries / 深圳市工业和信息化局战略性新兴产业发展专项资金扶持计划操作规程（2019）		"special funds"), this set of rules are formulated based on Shenzhen's policy on "special funds to support strategic emerging industry development".
November 19th, 2019	Special fund support policy for the development of strategic emerging industries in Shenzhen / 深圳市战略性新兴产业发展专项资金扶持政策（2018 – 2023）	Shenzhen's bureau of commerce	This policy applies to the new generation of information technology, high-end equipment manufacturing, green and low-carbon, biomedicine, digital economy, new materials, marine economy, and other key strategic emerging industries in Shenzhen. Shenzhen Treasury will arrange an annual budget to set up special funds to support the city's emerging industry.
June 8th, 2016	Suzhou municipal government's policies on accelerating the application of intelligent equipment and IoT / 关于加快智能装备和物联网应用的若干政策 (2016-2018)	People's Government of Suzhou	Suzhou will increase local financial support and give full play to the leverage of financial funds to support industrial enterprises to strengthen technical transformation and implement equipment upgrading. Enterprises are encouraged to adopt high-end intelligent equipment such as CNC machine tools, industrial robots, intelligent control systems, and complete automated production lines to improve production efficiency and product quality.
May 16th, 2016	Guidance of Yantai municipal people's government on promoting the development of robot industry (2016) / 烟台市人民政府关于推进机器人产业发展的指导意见	People's Government of Yantai	The policy plans to encourage enterprises, universities and scientific research institutions to speed up the construction of robot projects through supporting facilities in industrial parks and offer financial incentives, so as to form a supporting system for the development of the robot industry in Yantai, and strive to make the main business revenue of the city's robots and complete sets of robot equipment exceed 30 billion yuan by 2020.
February 13th, 2014	Three-year Action Plan for the Industrial Robot and Intelligent Equipment Sector (2015-2017) /洛阳市工业机器人及智能装备产业发展三年行动计划(2015-2017 年)	Luoyang's Ministry of Industry and Information Technology	Centering around users' demands from key industrial manufacturing areas, the city will carry out the task to implement system integration for industrial robots and intelligent equipment. Similarly, the city will also design, manufacture, test, and research the core components for industrial robot and intelligent equipment, such as precision gear reducers, servo drives,

			sensors, etc. to provide effective support for the healthy and sustainable development of industrial robot sector. Centering around users' demands from key industrial manufacturing areas, the city will carry out the task to implement system integration for industrial robots and intelligent equipment. Similarly, the city will also design, manufacture, test, and research the core components for industrial robot and intelligent equipment, such as precision gear reducers, servo drives, sensors, etc. to provide effective support for the healthy and sustainable development of the industrial robot sector. The city will accelerate the introduction of core technologies and key talents, and vigorously attract investment and cultivate local enterprises.
September 19th, 2017	Implementation opinions of Luoyang municipal people's government on further promoting the development of robot and intelligent equipment industry / 洛阳市人民政府关于进一步促进机器人及智能装备产业发展的意见 (2017)	Luoyang municipal commission of industry and information technology	By 2020, the city's robot and intelligent equipment industry shall achieve major breakthroughs in high-end products, improve quality reliability, market share, and leading enterprise competitiveness and built important domestic robot and intelligent equipment industry research and development production base.
March 20th, 2017	Three-Year Industry Plan for the Robotic Sector in Tianjin (2017-2020) /天津市机器人产业规划(2017-2020)	Tianjin's Development and Reform Commission	Tianjin is posited to set up a major program that will focus on intelligent robot technologies; the relevant projects are open solicitation nationwide with a subsidy amount of 500 thousand to 2 million yuan.
May 11th, 2018	Policies of Tianjin municipality on accelerating the development of intelligent technology industry /天津市关于加快推进智能科技产业发展的若干政策（2018）	Tianjin's Development and Reform Commission	We will seize major strategic opportunities in the development of the intelligent technology industry, strengthen policy guidance and support, focus on key areas of intelligent manufacturing, intelligent transformation of traditional industries, and intelligent applications, and increase support for "soft industries" such as the Internet, cloud computing, and big data to expand the intelligent technology industry.