UNDERSTANDING U.S.-CHINA DECOUPLING:

Macro Trends and Industry Impacts

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MESSAGE FROM STAFF EXECUTIVES

The U.S. and Chinese economies have become deeply intertwined in the last two decades. That interconnectedness has raised alarm bells in both Washington and Beijing in the wake of the COVID-19 pandemic and as competition accelerates between the two countries on strategic matters and advanced, innovative technology. Understanding both the fault lines and the benefits to the United States of our economic relationship with China as it stands now is critical to preparing for the relationship with China we want—and can live with—in the future.

The U.S. Chamber of Commerce's China Center has for the better part of two decades documented both the growth of the U.S.-China economic relationship and the challenges posed by China's trade and investment regime for U.S. competitiveness and market access. We have long advocated for a balanced and rational approach to commercial relations with China, one that recognizes the importance of a market of 1.4 billion people, while managing the realities of China's political and economic models.

This approach included both patience and enthusiasm for the progress toward opening in the years after World Trade Organization (WTO) accession, and, more recently, calling Beijing to account for policies that reversed course from the promises embodied by its entry, and which have put the state and Chinese Communist Party (CCP), rather than market forces, back in the driver's seat. Indeed, as China's international ambitions of becoming a global technology powerhouse have continued to rise—supported by the increasingly coercive use of economic statecraft globally—its commitment to open-economy, market-based norms has flagged in critical areas.

The two countries have attempted to disentangle aspects of our economies in recent years. As the U.S. Chamber of Commerce documented first in our 2010 report *China's Drive for Indigenous Innovation: A Web of Industrial Policies*, which focused on the policies and implementation tools Beijing deployed to reduce reliance on foreign technology, and subsequently in our September 2016 report *Preventing Deglobalization: An Economic and Security Argument for Free Trade and Investment in ICT*, the initial moves emanated from China. China's efforts accelerated in the later stages of Barack Obama's presidency with Made in China 2025 and continued throughout the Trump Administration. These and other reports from the Chamber provided the analytical foundation for the Trump Administration's 2017 Section 301 investigation into China's forced technology transfer policies, as well as other efforts to address China's industrial policies.

The United States responded in a measured way in the Obama years, and with increasing vigor under the Trump Administration, as we documented in our March 2019 report *Assessing the Costs of Tariffs on the U.S. ICT Industry: Modeling U.S.-China Tariffs*. Notwithstanding those efforts, the two economies remain deeply intertwined.

A new administration under President Joe Biden faces a difficult challenge in defining the next stage of economic engagement (or disengagement) with China. Deciding which areas do not pose a threat to national security—and should therefore be left open—is a complex task. Some argue that disengagement from China, through reshoring and investment in homegrown innovation, can boost economic activity in the United States. However, without an objective, fact-based examination of the costs and benefits of the U.S.-China economic relationship—and the economic impact of disentangling that relationship—that argument is purely speculative.

With this study, the U.S. Chamber of Commerce China Center seeks to educate policymakers, businesses, and other stakeholders to make informed decisions about serious challenges embodying difficult tradeoffs. By analyzing the economic impact of the scenario of a fully decoupled relationship, at least in certain key sectors, we hope to better illuminate the choices that policymakers will have to make to identify the optimal degree of economic engagement with China. In so doing, the U.S. Chamber of Commerce will continue to be a vocal proponent of open markets and free trade that is mutually beneficial, safe, and secure, while also remaining a vocal critic of trade and commercial practices that present challenges to the rules-based global economic order or are unfair to American businesses.

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EXECUTIVE SUMMARY

Conceived in 2019, this study seeks to illuminate the costs of decoupling for the United States. The analysis has been complicated over the past year by a shifting landscape. Tensions between the U.S. and China have grown in the aftermath of the COVID-19 outbreak, triggering a broader debate about supply chains, reshoring, and resilience. In truth, because of the many variables at play, it is beyond the capacity of economics to deliver a precise answer regarding the costs of decoupling. Nonetheless, this study offers what we believe is a valuable perspective on the magnitude and range of economic effects that the Biden administration should consider as it weighs its policy agenda with China. The study highlights the potential costs of decoupling from two perspectives: the aggregate costs to the U.S. economy and the industry-level costs in four areas important to the national interest.

Key findings of our assessment of the aggregate costs of decoupling to the U.S. economy include the following:

- **In the trade channel**, if 25% tariffs were expanded to cover all two-way trade, the U.S. would forgo $190 billion in GDP annually by 2025. The stakes are even higher when accounting for how lost U.S. market access in China today creates revenue and job losses, lost economies of scale, smaller research and development (R&D) budgets, and diminished competitiveness.

- **In the investment channel**, if decoupling leads to the sale of half of the U.S. foreign direct investment (FDI) stock in China, U.S. investors would lose $25 billion per year in capital gains, and models point to one-time GDP losses of up to $500 billion. Reduced FDI from China to the U.S. would add to the costs and—by flowing elsewhere instead—likely benefit U.S. competitors.

- **In people flows**, the COVID-19 pandemic has demonstrated the economic impact from lost Chinese tourism and education spending. If future flows are reduced by half from their pre-COVID levels, the U.S. would lose between $15 billion and $30 billion per year in services trade exports.

- **In idea flows**, decoupling would undermine U.S. productivity and innovation, but quantification in this regard is difficult. U.S. business R&D at home to support operations in China would fall and companies from other countries would reduce R&D spending related to their China ambitions in the U.S. The longer-term implications could include supply chain diversion away from U.S. players, less attraction for venture capital investment in U.S. innovation, and global innovation competition as other nations try to fill the gap.

In terms of industry-level costs, we find the following:

- **For the U.S. aviation industry**, decoupling would mean reduced aircraft sales resulting in lower U.S. manufacturing output, falling revenues for the firms involved, and thus U.S. job losses and reduced R&D spending—leading to diminished U.S. competitiveness. We estimate that a complete loss of access to China's market for U.S. aircraft and commercial aviation services would create U.S. output losses ranging from $38 billion to $51 billion annually. Cumulatively, lost market share impacts would add up to $875 billion by 2038.

- **For the U.S. semiconductor industry**, forgoing the China market would mean lower economies of scale and R&D spending—and a less central role in the full web of global technology supply chains. Decoupling would prompt some foreign firms to "de-Americanize" their semiconductor activities, putting to the test whether that is possible and further motivating China to seek self-sufficiency. Lost access to Chinese customers would cause the U.S. industry $54 billion to $124 billion in lost output, risking more than 100,000 jobs, $12 billion in R&D spending, and $13 billion in capital spending.

- **For the U.S. chemicals industry**, decoupling would mean a smaller U.S. share in China's growing market, diversification by China and others from U.S. suppliers, lost competitiveness, and lower R&D spending. This decrease would offset the newfound competitive advantages the U.S. enjoys from lower feedstock costs, thanks to improved extraction technologies. From the imposition of tariffs alone, the potential cost ranges from $10.2 billion in U.S. payroll and output reductions and 26,000 lost jobs to more than $38 billion in output losses and nearly 100,000 lost jobs.

- **For the U.S. medical devices industry**, decoupling would mean the added cost of reshoring supply chains and restricted product and intermediate input imports from China, along with retaliation against U.S. exports by Beijing. Abandoned market share in China would go to competitors, boosting their economies of scale and handing them future revenue from the market in China, where both rising incomes and an aging population are driving demand for medical devices. U.S. lost market share is valued at $23.6 billion in annual revenue, amounting to lost revenue exceeding $479 billion over a decade.

These estimations are derived from economic models of "normal" before the COVID-19 pandemic; the macroeconomic assumptions about future supply and demand that such models depend on must now be viewed with great skepticism. Moreover, they explore only the *economic welfare* effects: they do not attempt to price in the costs or benefits to U.S. *security*, which is a critical factor in the rethink of engagement with China. But the analysis does point to a number of important takeaways for U.S. policymakers, even with the caveats about the limits of economic modeling amid a global disruption:

- First, data analysis is critical to policymaking. China policy requires economic impact assessment, cost-benefit analysis, and a process of public debate and discovery.

- Second, even based on our rough assessment, we can see that the costs of anything approaching "full" decoupling are uncomfortably high. Alternative approaches—including mitigation and in many cases forbearance—would complement any decoupling scenario.

- Third, many elements merit inclusion in a comprehensive U.S.-China policy program, from promoting industry and innovation and technology to preserving the rules-based, open market order and its institutions, and protecting systemically and strategically important assets and industries from threats. In the policy reengineering to come, the central role of market forces in determining winners, and governments' finite capacity to redistribute resources to ease the process, must be respected.

- Finally, working with like-minded partners on a plurilateral basis to harmonize regulatory approaches in priority areas and to take coordinated actions that address shared concerns over China's practices is essential to minimizing the costs to the U.S. economy and preventing the erosion of U.S. comparative advantage that would occur if decoupling policies are implemented solely on a unilateral basis.

INTRODUCTION

The U.S. and China are integrated in a seemingly inextricable embrace by virtue of their direct relationship and their respective roles in the global supply chain. The direct trading relationship accounting for goods and services was $737.1 billion in 2018, before the start of the trade war. If one accounts for third country markets through which U.S.-China trade in intermediate goods pass, that number reaches even higher.

Yet the underlying policy assumptions fostering that integration are now being challenged in both countries. Basic calculations about respective strategic and economic intentions have changed, and an implicit bargain between Beijing and Washington about the trading relationship seems to have broken. The resulting policy debates in both countries therefore have far-reaching consequences. There are legitimate reasons for both parties to consider an alternative relationship, but if the U.S. and China were to systematically close off economic engagement—in a word, *decouple*—it would not come without costs.

Identifying the real consequences and costs of decoupling is urgent because initial steps toward such an act have already been taken. The U.S. is debating (both in public and in private strategy discussions) whether and how to continue down this path. The prospect of U.S.-China decoupling has never been more real.

The U.S. Chamber of Commerce's China Center has long advocated for a balanced and rational approach to commercial relations with China. This approach included both patience and enthusiasm for the progress toward opening in the years after World Trade Organization (WTO) accession,[1] and—increasingly—calling Beijing to account for policies that reversed course from the promises embodied by entry into the WTO, policies that put the state and Chinese Communist Party (CCP), rather than market forces, back in the driver's seat. Yet as China's international ambitions have continued to rise, supported by the increasingly coercive use of economic statecraft, its commitment to open-economy, market-based norms has flagged.

From China's Indigenous Innovation initiatives in 2009, to Made in China 2025 in 2015, to a new generation of state controls on data, Beijing has deployed a mix of market access limits, industrial policies, and regulatory restrictions to support the competitive position of domestic companies and reduce dependence on foreign technology and expertise. Most advanced economies choose to cushion the effects of market liberalism for political or security reasons, but the scope and intensity of China's departure from those norms is far-reaching. Beijing has made explicit its plans to overtake and displace leading international technology companies, sparking understandable concerns about the global economic playing field and national security. Most troubling, although in the past these statist impulses jostled for influence with less interventionist, liberal approaches, this debate is largely stifled today.

Additionally, China has recently enacted new measures to blunt the impact of national security and foreign policy measures enacted by other countries, including the Ministry of Commerce's January 2021 "blocking order,"[2] which threatens to subject companies from third-party countries that comply with U.S. export controls and secondary sanctions to civil compensation claims in Chinese courts that lack impartiality. The measures, which appear

1 See, for instance, Tom Donohue in February 2004:

> Do we engage China in constructive dialogue, or do we try to get our point across through confrontation, isolation, and trade barriers? Do we encourage China's development and its full participation in the global economy, or do we try to slow its growth out of irrational fears about our own competitiveness? In this time of challenge and opportunity for the global economy and in U.S.-China relations, the business community must lead the way. Lead the way to a renewed commitment to open markets, a more transparent system based on the rule of law, and business environments in both countries where companies—no matter what their nationality—can grow and prosper.

Thomas Donohue, "U.S.-China Relationship: The Truth Behind the Rhetoric," Remarks Before the Asia Society CEO Series Luncheon Forum, February 25, 2004. https://www.uschamber.com/speech/us-china-relationship-truth-behind-rhetoric-address-thomas-j-donohue

2 MOFCOM, "MOFCOM Order No. 1 of 2021 on Rules on Counteracting Unjustified Extra-territorial Application of Foreign Legislation and Other Measures," January 2021. http://english.mofcom.gov.cn/article/policyrelease/announcement/202101/20210103029708.shtml.

derivative of China's Unreliable Entity List,[3] were enacted in contravention of China's formal legislative review process. They are also written in a vague manner that leaves open the possibility that the CCP could apply the rules directly to U.S. subsidiaries in China. In many respects, this and other Chinese government efforts to neuter the national security and foreign policy measures of other countries come across as ironic, as China continues to rapidly build out its own extraterritorial laws and regulations in areas ranging from export controls[4] to data security.[5]

Beijing's intensifying shift to illiberalism has changed the China policy conversation in Washington over the past decade, and is now prompting hard questions elsewhere as well. By the mid-2010s, many in Washington felt that China was more of a competitor than a partner. By the end of the Obama era, Washington was pushing back against Beijing with stricter investment screening,[6] while closely scrutinizing high technology vulnerabilities in the semiconductor industry.[7] An initiative by the Defense Department's Defense Innovation Unit—supported by the Office of Commercial and Economic Analysis—to push back on techno-nationalism paved the way for many of the policies that have since been rolled out.

In recent years, the national security establishment, generally with bipartisan support from Congress, has altered the U.S. strategic framework with China. The December 2017 National Security Strategy asserted that engagement as a strategy had not been effective, labeled China a strategic competitor, and redefined the contest to include economic and normative concerns, not just security interests. As that document lays out:

> These competitions require the United States to rethink the policies of the past two decades—policies based on the assumption that engagement with rivals and their inclusion in international institutions and global commerce would turn them into benign actors and trustworthy partners. For the most part, this premise turned out to be false.[8]

On the basis of that strategic shift, less permissive policies toward China were developed across the whole of the U.S. government. Examples have included a more restrictive approach to foreign acquisitions of U.S. firms due to security concerns (Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA)); the expanded use of export controls to prevent transfers of sensitive technologies (Export Control Reform Act of 2018 (ECRA)); the extraordinary imposition of tariffs under Section 301 and other trade policy authorities; the exclusion of students and researchers with military affiliations; and the closure of a consulate and expulsion of journalists tied to concerns over economic espionage, state control over the Chinese media, and reciprocity. This approach has come to be referred to as *decoupling*.

U.S. decoupling policies differ from Chinese efforts to reverse course on economic liberalism. Beijing has selectively constrained private and foreign business interests in recent years; it has continued to lure foreign economic

3 MOFCOM, "MOFCOM Order No. 4 of 2020 on Provisions on the Unreliable Entity List," September 2020.
http://english.mofcom.gov.cn/article/policyrelease/questions/202009/20200903002580.shtml

4 National People's Congress, "Export Control Law of the People's Republic of China," October 2020, Article 44.
http://www.npc.gov.cn/npc/c30834/202010/cf4e0455f6424a38b5aecf8001712c43.shtml

5 National People's Congress, "Data Security Law of the People's Republic of China (Draft)," June 2020, Article 2.
Full translated text: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-chinas-data-security-law-draft/;
National People's Congress, "Personal Information Protection Law of the People's Republic of China (Draft)," October 2020, Articles 42, 52.
Full translated text: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/chinas-draft-personal-information-protection-law-full-translation/

6 James K. Jackson, "The Committee on Foreign Investment in the United States (CFIUS)," Congressional Research Service, February 14, 2020.
https://fas.org/sgp/crs/natsec/RL33388.pdf

7 See: President's Council of Advisors on Science and Technology, "Ensuring Long-Term U.S. Leadership in Semiconductors," Executive Office of the President, January 2017.
https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_ensuring_long-term_us_leadership_in_semiconductors.pdf;
Michael Brown and Pavneet Singh, "China's Technology Transfer Strategy: How Chinese Investments in Emerging Technology Enable a Strategic Competitor to Access the Crown Jewels of U.S. Innovation," Defense Innovation Unit Experimental, January 2018 (latest update).
http://nationalsecurity.gmu.edu/wp-content/uploads/2020/02/DIUX-China-Tech-Transfer-Study-Selected-Readings.pdf

8 White House, "National Security Strategy of the United States of America," December 2017.
https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf

participation into the market, albeit on its own terms. China's policy priority to maintain a tightly managed inflow of foreign investment is as evident as ever today. The U.S. policies, by contrast, are based on two principal motives: weeding out economic interactions, whether outbound or inbound, that are driven by security-related aims; and/or forcing greater reciprocity and fairness.

Broader deterioration in the U.S.-China relationship has accelerated this drive to dial down economic engagement with China. Aggressive posturing from China on its periphery and at home—in the South China Sea, with Vietnam, with Australia, with India, with Taiwan, in Hong Kong and Xinjiang—has heightened concerns. Extrajudicial detentions of foreign citizens in China and the attempt to project Chinese laws abroad to suppress free speech and shape a narrative favorable to the CCP is souring U.S. sentiment.[9] In 2020 alone, China's leaders asserted that the state and its enterprises will remake the allocation of capital, labor, and data and determine the fate of the private sector. All of this colors public opinion in the U.S. and other democratic countries, reducing the scope for constructive dialogue and compromise.

More restrictive attitudes toward China are not limited to the U.S. For example, countries like Australia, France, India, Japan, Singapore, and the United Kingdom have taken steps to prevent telecom giant Huawei from building their 5G telecommunications networks. Most Organization for Economic Co-operation and Development (OECD) nations have stepped up their foreign investment screening systems in response to Chinese acquisitions in strategic sectors. And many are planning to reduce their dependence on China-based supply chains in light of the pandemic and the spectacle of "mask diplomacy."

Although the Trump administration has rallied some allied support for addressing China-related security concerns, plurilateral progress on economic policy matters has been limited by certain unilateral actions and rhetoric that allies do not support. No other nation has been willing to talk openly about a new Cold War, disrupt the World Trade Organization (WTO), or leave the World Health Organization (WHO) over China. The Biden administration indicated very early on that it would prioritize coalition building with allies to address China. Some preliminary work on that objective has been undertaken, and much more is needed. The potential for a common policy among advanced economies toward China is there, but it is far from clear if these nations can reconcile differences over how to achieve such a united front.

Notwithstanding all these tensions, the world's two largest economies remain coupled in many ways. U.S. firms have hundreds of billions of dollars of assets and tens of thousands of people at work in China: it is a global manufacturing leader, has a large and growing middle class, and has put vast resources into innovation and R&D. China's quick recovery from the COVID-19 pandemic has bolstered its attractiveness: in 2020 it is likely to be the only major economy to show growth.

Going forward, there is bipartisan support for a more forceful approach to China, as well as growing public concern over Beijing's policies. In this environment, the Biden administration is likely to face political backlash if it tries to return to the previous policy of engagement with China. Although the direction of policy is clear, the future shape and pace of U.S. disengagement from China is not; this question must be considered with care due to its implications for the U.S. business community and national security. An approach to decoupling that is targeted and fact-based will be more appealing for U.S. allies and therefore have a better chance of success in the long run. But regardless of how future policy evolves, understanding the economic costs of decoupling should be a fundamental priority. This study explores those costs—broken down into the flow of goods, investment, ideas, and people—for the U.S. economy broadly and across four selected industries: aviation, semiconductors, chemicals, and medical devices.

9 Laura Silver, Kat Devlin, and Christine Huang, "Unfavorable Views of China Reach Historic Highs in Many Countries," Pew Research Center, October 6, 2020. https://www.pewresearch.org/global/2020/10/06/unfavorable-views-of-china-reach-historic-highs-in-many-countries/

HOW WE GOT HERE

China's Industrial Policy and the Origins of Decoupling

The surge of Trump-era economic decoupling policies in the U.S. is rooted in national security concerns about the fusion of state strategic interests and private commercial motivations in China, as well as growing asymmetries in market access and the terms of global competition. China has long had industrial policies designed to bolster national strength both in security and material terms. But until recently, such concern was mitigated by two factors. First, across seven decades, those policies typically did more developmental harm than good, and the gap between U.S. and Chinese capabilities was not closing. Second, there were effective advocates for a less statist, more market-oriented solution to China's economic questions in Beijing. By the end of the 2010s, these mitigating factors had diminished. China's nonmarket economic policies and too-often discriminatory and mercantilist practices were affecting the national security and competitiveness of other countries. Voices supporting economic liberalism inside China were silenced. In this context, commercial imbalances and advantages (like no-risk financing) enjoyed by many Chinese firms at home and abroad became less and less tolerable.

Washington and other like-minded capitals pursued a policy of *engagement* with China because Beijing was gradually moving to a rules-based, open market system. From the start of the reform era in 1978 through accession to the WTO in 2001, evidence of China's convergence with market norms was ample. Prices, virtually all state-planned under a shaky Soviet-style "material production system" in 1978, were almost all market-determined by the late 1990s. Scores of state-owned enterprises were downsized or eliminated throughout the economy. Tariffs and other nontariff barriers were reduced to among the lowest in the emerging market world. China permitted more widespread foreign investment presence than even advanced nations like Japan and Korea allowed. Gauged by objective metrics such as new business entry and profit margins, China was engaged in not only economic retooling, but genuine, market-oriented reform and opening.

However, as early as 2006, there was growing evidence of a reversal of the steady displacement of the state sector by private enterprise, and with the onset of the global financial crisis, analysts were far from confident that the state-led cyclical response to the 2008-10 recession would represent a temporary policy adjustment rather than longer-term divergence from market-oriented reforms. Despite the indications of opening and marketization in past decades, state distortions had consistently played a decisive role in China's economy, and without visible progress on marketization, the case for patience weakened. Against that backdrop, the U.S. business community has worked over the past decade to document its concerns, in hopes that such attention would promote resolution. For instance:

- In 2010, the U.S. Chamber published "China's Drive for Indigenous Innovation," which focused on the policies and implementation tools Beijing deployed to reduce reliance on foreign technology.[10] The guiding document of the Indigenous Innovation strategy, "The National Medium- and Long-Term Plan for the Development of Science and Technology (2006-2020)," instructed Chinese companies to import foreign technology only to assimilate, absorb, and reinnovate it.[11] The plan mandated that domestic technology replace foreign technology in core infrastructure. Patent rules, product testing and approval regimes, antimonopoly law, government procurement, and technology standards formed Beijing's policy toolkit to reduce reliance on foreign technologies. The Chamber warned, "these indigenous innovation industrial policies are headed toward triggering contentious trade disputes and inflamed political rhetoric on both sides."[12]

10 James McGregor, "China's Drive for Indigenous Innovation: A Web of Industrial Policies," U.S. Chamber of Commerce, 2010. https://www.uschamber.com/sites/default/files/legacy/international/asia/files/100728chinareport_0.pdf

11 State Council of the People's Republic of China, "Guidelines for the Implementation of the National Medium- and Long-Term Plan for Science and Technology Development (2006–2020)," February 2006. Full translated text: https://www.itu.int/en/ITU-D/Cybersecurity/Documents/National_Strategies_Repository/China_2006.pdf

12 James McGregor, "China's Drive for Indigenous Innovation: A Web of Industrial Policies," U.S. Chamber of Commerce, 2010. https://www.uschamber.com/sites/default/files/legacy/international/asia/files/100728chinareport_0.pdf

- The U.S. Chamber's 2012 study "China's Approval Process for Inbound Foreign Direct Investment" detailed how China's FDI regime is the most restrictive among all G20 economies.[13]

- In 2014, the U.S. Chamber's report "Competing Interests in China's Competition Law Enforcement" reviewed the first five years of the implementation of China's Anti-Monopoly Law (AML) and found that AML remedies prioritized industrial policy over competition law.[14]

- In 2016, the U.S. Chamber catalogued China's efforts to favor domestic products and services over foreign ones in "Preventing Deglobalization: An Economic and Security Argument for Free Trade and Investment in ICT." The report focused on China's ambition to localize its information and communication technology (ICT) sector, an endeavor that we estimated would cost China $3 trillion in lost GDP by 2025.

- The U.S. Chamber's 2017 report "Made in China 2025: Global Ambitions Built on Local Protections" documented the intensification of China's state-led approach and Beijing's apparent embrace of the global economy as a means to expand global market share for Chinese companies while maintaining nonreciprocal restrictive policies at home.[15] The report detailed preferential treatment of Chinese companies under Made in China 2025 (MIC 2025) through a range of policy tools including market access, licensing, regulations, standards, national and cybersecurity reviews, and procurement. The study warned at the time that MIC 2025 was "likely to put the U.S. and China on a path of separation rather than integration."

- China's protectionist policies are continuing into the 2020s, as reflected in the country's emerging data regime. The Chinese roadmap for becoming a "data superpower" features a restrictive data governance regime to protect local companies and force global competitors to localize data storage and processing. The state uses large subsidies and procurement plans to support national data champions. Of particular concern to U.S. policymakers are the requirements in Chinese law—including the National Security Law, Cybersecurity Law, and (draft) Data Security Law—that require private companies to provide data to authorities, compel private entities to cooperate on intelligence matters, and limit the export of certain data.

State policies and increasing CCP control over all aspects of society set the scene for the U.S. policy response, which is now referred to as *decoupling*. Beijing is ardent as ever about attracting global multinational firms and professionals and about drawing in portfolio investment—the global component of the "dual circulation" strategy. And though it has been obscured somewhat by the disruption of the COVID-19 pandemic, Beijing has pressed ahead with global lending, direct investment in the advanced economies, trade agreements like the Regional Comprehensive Economic Partnership (RCEP), and efforts to assert leadership on global issues such as climate change. But these engagements have been increasingly dictated on state-led and coercive terms, rather than based on market principles. In short, China has itself decoupled from the prospect of convergence with liberal market economic norms, while at the same time publicly promoting deeper engagement.

13 U.S. Chamber of Commerce, "China's Approval Process for Inbound Foreign Direct Investment," 2012. https://www.uschamber.com/sites/default/files/documents/files/020021_China_InboundInvestment_Cvr.pdf

14 U.S. Chamber of Commerce, "Competing Interests in China's Competition Law Enforcement," 2014. https://www.uschamber.com/sites/default/files/aml_final_090814_final_locked.pdf

15 U.S. Chamber of Commerce, "Made in China 2025: Global Ambitions Built on Local Protections," 2017. https://www.uschamber.com/sites/default/files/final_made_in_china_2025_report_full.pdf

The U.S. Response

The sea change from emphasizing engagement and cooperation to seeing China as a competitor and systemic rival was spelled out by the U.S. in late 2017 after extensive internal deliberation. The December 2017 National Security Strategy (NSS) stated that China (and Russia) sought to do the following:

> [C]hallenge American power, influence, and interests, attempting to erode American security and prosperity. They are determined to make economies less free and less fair, to grow their militaries, and to control information and data to repress their societies and expand their influence.[16]

This conviction sprung from long-standing concerns in the career national security community, with the illiberal drift in Chinese economic policy after 2010 deepening concerns about national security. Pre-Trump examples of the shift in Washington included the following by the Obama administration:

- Release of the seminal report "Ensuring Long-Term U.S. Leadership in Semiconductors," which put forward recommendations for how to mitigate the threat posed by Chinese industrial policy[17]

- Heightened scrutiny over technology investments, including the $1.3 billion bid by Canyon Bridge (a firm with ties to China) to buy Lattice Semiconductor, Tsinghua Unigroup's $3.8 billion bid for a stake in Western Digital, and coordination with allies to block China's Fujian Grand Chip Investment Fund's $730 million bid for Aixtron SE (a German semiconductor equipment maker)

- Use of export controls to block the sale of high-end computer chips to supply a Chinese supercomputer project over fears that it would strengthen China's nuclear research capabilities

- Secretary of Defense Ash Carter commissioning the Defense Innovation Unit Experimental's report "China's Technology Transfer Strategy," which was released early in the Trump administration and detailed China's high-tech ambitions and called for Committee on Foreign Investment in the United States (CFIUS), export control, immigration policy, and counterintelligence reforms to curtail China's access to U.S. technology[18]

All of this predated the more avowedly muscular China policies of the Trump administration, but was less pronounced amid parallel Obama administration efforts to cooperate with China to address climate change risks, deal with pandemic preparedness, and generally look for mutually beneficial opportunities. Under former President Trump, the scope and scale of policy pushback against China expanded greatly and was reinforced by the NSS document, multiple doctrinal speeches, and a demonstrated willingness to disrupt business as usual. At the same time, the "real" U.S. endgame was often clouded by the transactional framework pursued by the White House on trade and market access issues.

The Biden administration may adopt a less strident tone with China and is likely to prioritize working with allies. This, in and of itself, will mean a shift in policy toward China. But in many important respects, including the emphasis on competition and a broad view of the challenges China poses across economic, political, technology, and security dimensions, there is likely to be continuity.

16 White House, "National Security Strategy of the United States of America," December 2017. https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf

17 President's Council of Advisors on Science and Technology, "Ensuring Long-Term U.S. Leadership in Semiconductors," January 2017. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_ensuring_long-term_us_leadership_in_semiconductors.pdf

18 Michael Brown and Pavneet Singh, "China's Technology Transfer Strategy," Defense Innovation Unit Experimental, January 2018. https://admin.govexec.com/media/diux_chinatechnologytransferstudy_jan_2018_(1).pdf

UNDERSTANDING THE SCOPE

As recently as 2018, large-scale U.S.-China decoupling seemed unlikely given the interconnected and interdependent nature of the two-way relationship. Since then, disengagement expectations have broadened from trade and high-tech FDI to include most all areas, ranging from the flow of goods and portfolio investment to restrictions on journalists and students. In each of these channels, the state of play has moved from concept to implementation.

Comprehensive decoupling is no longer viewed as impossible: if the current trajectory of U.S. decoupling policies continues, a complete rupture would in fact be the *most likely* outcome. This prospect remains entirely plausible under the Biden administration. Many U.S. firms are making visible adjustments to prepare for or hedge against such an outcome, and firms from other parts of the world are asking whether they will be the beneficiaries or, rather, if their own home governments will follow suit. In Appendix 1 we catalogue U.S. decoupling measures—enacted or proposed—organized into four clusters: trade, investment, ideas, and people. We show the current scope and whether the measure has been enacted (as of January 21, 2021; new policies continue to emerge).

In each of these four economic channels, some degree of decoupling has already occurred, especially when gauged against the pre-2017 baseline of typical growth in economic interaction. Trade is way down from the 2017 benchmark used for the Trump administration's Phase One Agreement; two-way FDI is at a decade low; tourism and student exchanges were projected to decline even pre-pandemic and now have plummeted; and supply chains in telecommunications and semiconductors are being profoundly and permanently cut by Washington's view of China's technology national champions as national security risks. In both Washington and Beijing, political trust is at a nadir, and a return to the cooperative engagement policy that dominated the relationship since 1972 is difficult to imagine absent a sea change in both capitals.

Taken together, this means momentum toward decoupling functions as a gravitational pull. De-escalation would be the much harder of the two options. Other facets of decoupling outside the commercial sphere add to the picture. Military-to-military engagement has been irregular; diplomatic relations have been curtailed with the closure of consulates; cooperation in international organizations, including the WTO and WHO, has been curbed. Decoupling is real, and given bipartisan support for it in the U.S., it is likely to endure in one form or another.

There is a strong rationale to limit decoupling to segments of trade, investment, people flows, and technology that meaningfully impair U.S. national security, and not to act gratuitously without regard for economic welfare. In financial services, Beijing is continuing to open its doors wider. In the auto sector, foreign firms are being granted more control. Because there is no strategic problem in many sectors[19] or because Beijing is offering greater inducements, many industries can present a strong countercase to decoupling. But this will not call into question the core driver of the decoupling debate: China's embrace of state control and its distorting effect on liberal, rules-based, open market economies like that of the U.S. —especially in terms of technology security and genuine access that allows for cross-border delivery of goods and services. The systemic rivalry between the U.S. and China is likely to intensify, animating this public policy debate and compelling political leaders in the U.S. and other democracies to offer a response. Policymakers will need a better understanding of the costs of decoupling as this situation unfolds.

19 Agatha Kratz, Matthew Mingey, and Daniel H. Rosen, "Exploring a 'Green List' for EU-China Economic Relations," Rhodium Group, September 29, 2020. https://rhg.com/research/green-list/

THE AGGREGATE COSTS OF U.S.-CHINA DECOUPLING

Pulling two huge economies apart will be expensive. At $15 trillion, China is the second largest economy on the planet next to that of the U.S., which boasted more than $21 trillion prior to COVID-19. In 2018, before the trade war tariffs were fully implemented, U.S.-China goods and services trade amounted to $737.1 billion, the cumulative value of two-way direct investment since 1990 surpassed $386 billion (as of June 2020),[20] cooperation on R&D was increasing, and China was the largest source of international students and fifth largest source of arrivals in the U.S. In 2019, China contributed 35% of marginal global growth—almost twice as much as the U.S., the European Union, Japan, and Canada combined.

The costs of forgoing the China market are substantial, in terms of the direct loss of potential revenue but also indirectly, as firms from other nations that remain engaged pick up vacated Chinese market share in America and U.S. market share in China, improving their economies of scale and scope at the U.S.' expense. Higher import costs for intermediate products and final products, and the cost of replacing supply chains in China with new networks elsewhere, add to the bill. And this is just the starting point: in addition to direct costs there are second-order, long-term costs. Examples include lost efficiency due to diminished U.S. competitiveness and less international trust in the U.S. as an open economy. To determine the best balance between national security and economic welfare, it is important to have a picture of these costs.

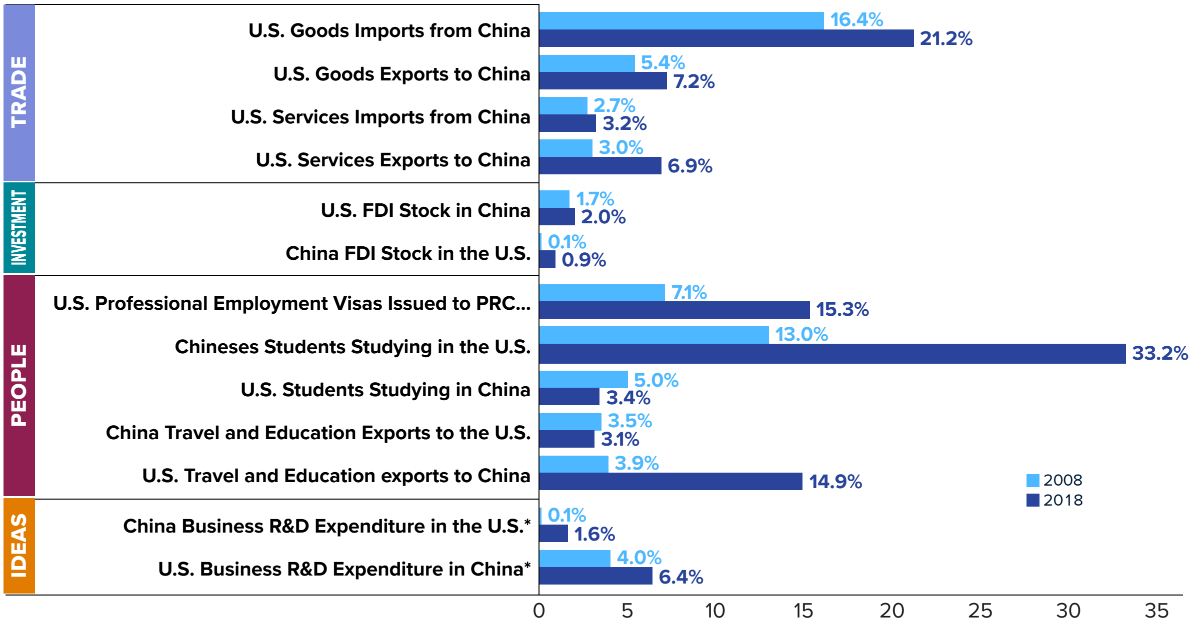
To explore the costs of decoupling, we consider four channels of activity: trade, investment, ideas, and people. This does not include all facets of the bilateral economic relationship but covers the major elements. Each of these channels of economic intercourse is complex and supports vast amounts of activity, including commerce, jobs, research, and education. Under any circumstances, a precise tally of the value of all this is difficult. Today the macroeconomic shock of COVID makes it virtually impossible to discern the welfare effects of specific decoupling policies amid all the other disruption. Therefore, given the present challenge, this exploration of the U.S. costs of decoupling is a rough sketch, not a full tally. Where costs are intangible or incalculable absent complex economic models, we explore them qualitatively.

U.S.-China economic engagement in each of these four channels is extensive. Figure 1-1 summarizes China's weight in U.S. economic activity in 2018 compared with 2008, showing the current level and the degree of change over a decade. Several things are notable. First, interaction is uneven across these channels. U.S. goods imports from China are huge, while exports to China are more modest, and services trade in both directions is at single-digit levels (though growing fast in the case of U.S. exports). Second, student and professional flows between the two countries have been booming, which correlates with the doubling in U.S. services exports (e.g., students, tourists) and points to the contributions of Chinese citizens working in the U.S. And third, the majority of these interactions are still far from their potential peak values.

20 Rhodium Group and the National Committee on U.S.-China Relations, "The U.S.-China Investment Hub," accessed October 2020. https://www.us-china-investment.org/fdi-data

Figure 1-1: U.S.-China Engagement in Four Channels as a Share of Total U.S. Activity+

Percentage



Sources: U.S. Bureau of Economic Analysis, U.S. Census Bureau, Institute of International Education, Rhodium Group (RHG) calculations. +R&D expenditure is for the years 2009 and 2017. *Shows U.S. outbound activity in China as a share of total U.S. outbound activity, and U.S. inbound activity from China as a share of total inbound activity in the U.S. China does not publish data on U.S. professional visas issued.

From this baseline picture of U.S.-China economic engagement in four channels, a conventional assessment of the costs of decoupling would assume a reasonable rate of growth based on past patterns and then project reductions in activity attributable to decoupling. But extrapolating the future based on pre-COVID baselines is no longer reasonable. The assumptions about growth rates, productivity, and even reliance on trade for pharmaceuticals, masks, ventilators, and innumerable other items deemed essential in a crisis are antiquated. Models such as GTAP traditionally used to analyze international trade policy shocks were showing their limits before the pandemic; calibrating them (as is required) with yesterday's assumptions about GDP growth and productivity is an imperfect art. Aggregate models are most useful for conceptualizing the complex effects of decoupling and getting the magnitude of impacts in four channels of engagement right. Industry case studies, presented in the next section, are more useful in understanding real-world dynamics and impacts.

A note about the aggregate estimates below: In these four subsections, we look at ways to ascribe a ballpark value to these channels. These estimates are not comprehensive, nor are they adjusted to be on the same base year or to be compatible with each other. Each discussion stands alone and pertains to one channel, and the four cannot be cumulated to provide a precise reckoning, only a notional order of magnitude picture. That is sufficient for our purpose—to gauge the broad stakes for the U.S. in pursuing a decoupling campaign, so that the necessary resources are considered. Throughout our discussion, the phrase *full decoupling* is defined as bilateral flows going to zero, and the less severe but still disruptive *hard decoupling* scenarios are defined within each section.

Trade

What might be plausible in a hard decoupling scenario has evolved, even during the drafting of this study. In late 2019, when we began, extending the 25% maximum Section 301 tariffs from many products to all products, permanently, was seen as an extreme outcome. By fall 2020, there were additional U.S. export prohibitions in place in select areas, with the rising prospect of additional trade restrictions on large Chinese firms, many of which are tied to military-civil fusion and human rights concerns.

Looking ahead, the possibility that hard decoupling could mean full, comprehensive decoupling is no longer unthinkable, although the Trump administration's decoupling actions fell far short of the scope and depth of measures that would be required to fully decouple. Given current trends, more robust analysis is urgently needed to determine the economic cost of full decoupling, including on a sectoral basis.

Existing models explore only one hard decoupling outcome that was once considered to be extreme: extending the 25% Section 301 tariffs to *all two-way trade*. That shock would result in over $190 billion in lost annual U.S. output in 2025, with losses surpassing $250 billion by 2030.[21] Cumulatively, the U.S. economy stands to come up $1 trillion short of its potential growth over the coming decade after full tariff implementation.[22] Yet the models do not explore the impact of full trade decoupling. Trade decoupling means forgoing market access not only today, but ever more importantly, for years to come (assuming Beijing can overcome mounting headwinds to growth—a big uncertainty). China may well be an even larger share of marginal global growth in the future than the 35% it represented in recent years, given post-COVID relative growth rates compared with those of the U.S. and other advanced economies. Meanwhile, America's peer competitors stand to pick up market share and the economies of scale and competitiveness that come with it.

Investment

Over the more than 40 years since China commenced its economic reform and opening, U.S. businesses have built a significant asset base in China. A simple count of initial investment values tallies to $258 billion in cumulative U.S. FDI transactions in China as of June 2020.[23] If capital gains, accrued good will, and reinvested earnings are taken into account, U.S. official estimates from the Bureau of Economic Analysis (BEA) go as high as $764 billion.[24] In a full decoupling scenario, intangible good will value cannot be brought home, and brick and mortar assets would be sold deeply discounted at best. A hard decoupling outcome might mean that the stock of U.S. FDI in China falls by half (versus a complete sell-off and write-down, as in 1949, under full decoupling). Assuming that capital generates 20% in returns a year, a 50% reduction from the $258 billion in cumulative U.S. FDI in China cited above would mean lost capital income to U.S. investors of about $25 billion a year.[25] The BEA's alternative estimate could triple that imputed number.

That is far from the end of the story. Research shows a relationship between capital spending by U.S. multinationals abroad and at home. Each dollar of U.S. multinational firm capital at work abroad historically increases U.S. GDP in the aggregate. If that relationship holds for China (and examining that is one purpose of the industry deep dives included in this report), then a 50% fall in U.S. FDI presence in China ($124 billion) could reduce U.S. GDP by four times that amount ($500 billion) annually. Both of these costs—direct loss of profits in China from withdrawing from the market and indirect hits on output back home—are important, and together they could sum to as much as $550 billion in U.S. impact per year under the hard decoupling scenario.[26]

21 U.S. Chamber of Commerce, "Assessing the Costs of Tariffs on the U.S. ICT Industry: Modeling U.S.-China Tariffs," March 2019.
https://rhg.com/wp-content/uploads/2019/03/RHG_AssessingCostsofTariffson-USICTIndustry.pdf

22 Ibid.

23 Rhodium Group and the National Committee on U.S.-China Relations, "The U.S.-China Investment Hub," accessed October 2020.
https://www.us-china-investment.org/fdi-data

24 U.S. Bureau of Economic Analysis, "Activities of U.S. Multinational Enterprises (MNEs): All Foreign Affiliates by Country," 2018, accessed June 2020.
https://www.bea.gov/international/di1usdop

25 Economic evidence shows return to capital around 20% in recent years. Sun Wenkai et al., "Investment Rate and FDI—A Comparative Analysis of Return to Capital among China, U.S. and Japan," Brookings Institution, May 2012.
https://www.brookings.edu/wp-content/uploads/2012/05/Ex3Paper2Xiao-Sun-Yangen.pdf

26 Academic research indicates that outbound investment by domestic firms complements domestic investment, rather than replaces it as is commonly thought. Desai et al. (2005) concluded that one dollar of additional capital expenditure by U.S. multinationals abroad is associated with $3.5 of capital spending at home, and almost $4 of GDP increase. Using BEA data ($116.5 billion in 2018 U.S. FDI in China) and the historic trend, we estimate the "normal" (free from decoupling shocks) 2020 U.S. FDI stock in China to be $140 billion. Based on the relationship between reductions in capital stock and GDP presented in Richards and Schaefer (2016) we use coefficients to calculate the cost to GDP of lost bilateral FDI. We take 2020 as a base for calculation under pre-COVID growth projections. See our methodological appendix for a walk through of these rough calculations. See also: Desai et al., "Foreign Direct Investment and the Domestic Capital Stock," *The American Economic Review* Vol. 95, No. 2 (May 2005), pp. 33-38.
https://www.jstor.org/stable/pdf/4132786.pdf;
Julian Richards and Elizabeth Schaefer, "Jobs Attributable to Foreign Direct Investment in the United States," *Industry and Analysis Economics Brief*, Office of Trade and Economic Analysis of the U.S. International Trade Administration, February 2016.

On the one hand, unlike U.S. FDI in China, FDI from China to the U.S. is mostly acquisitions rather than greenfield investment, so the implied cost (to the U.S.) of it drying up is lower. On the other hand, Chinese firms have been willing to invest in places that other investors were not, such as "rust belts." Alternative investors are unlikely to fill all the gaps, and there are indirect knock-on effects as well. A U.S.-China hard decoupling that decimates Chinese investment in the U.S. will also cause firms from third nations to rethink their U.S. investment plans. They will worry about being caught in the U.S. policy gauntlet and prevented from servicing China from operations in the U.S. That is not just theoretical: BMW and Daimler manufactured 60% of the autos shipped from America to China in recent years, and both firms are now thinking twice about using the U.S. as a global production platform.[27]

Portfolio investment flows would be curtailed in a hard decoupling scenario too; indeed, there have been very modest moves in this direction already, in the form of White House pressure on government pension managers to reduce investment in China.[28] There is a stock of approximately $3.9 trillion in bilateral portfolio investment, not including China's central bank holdings of U.S. Treasuries.[29] Two-way financial investment has actually risen during the COVID-19 pandemic, as high Chinese interest rates have attracted global money looking for yield in a stagnant world. U.S. financial service providers would miss out on intermediating trillions of dollars of Chinese savings, and—if China maintains growth—U.S. savers would sit out the higher returns that China is delivering. An uptick in China's "nonhome bias" in its investment behavior (the portion *not* invested domestically), producing a shift in foreign portfolio investment by residents of China from the current 2% to 10% (compared with global averages of 37% for equities and 25% for bonds[30]), would translate to $2 trillion in new Chinese portfolio outflows. The U.S. stands to be a major destination for that capital redeployment, but it will go elsewhere—to London, Singapore, or other capital centers—if decoupling proceeds. These direct impacts would be compounded too, as the central role of the U.S. as the crossroads of global capital flows comes under question.

People Flows

Decoupling is likely to shrink the talent pool that industries of the future will draw from, adding to the risks facing U.S. technology and innovation leadership. Even prior to COVID-19, bellicose pronouncements from both sides, investigations, restrictive policies, and signals of aggressive future treatment of business professionals, students, and other natural persons traveling back and forth had chilled this important economic channel in the U.S.-China relationship.[31] Excluding Chinese students from high technology and advanced sciences as fields of study will deplete U.S. universities of income and prevent U.S. firms, including those looking to onshore new high-tech activity, from staffing.

Table 1-1 shows the scope of people flows prone to decoupling, prior to the pandemic. The largest near-term U.S. impacts from restrictions on the flow of people would occur in tourism and education. These effects show up as a reduction in U.S. services exports to China, narrowing the U.S. surplus in this category; in fact, travel, which includes tourism and education, is the largest U.S. export to China by category. These 2018 figures had grown steeply in recent years and would likely have expanded further absent political interruption or, of course, the COVID-19 pandemic. Although the virus radically reduced physical movements in the first half of 2020, and continues to do

27 Oliver Sachgau and David Welch, "BMW, Mercedes-Benz Ensnared Again in U.S.-China Trade War," Bloomberg News, August 23, 2019. https://www.bloomberg.com/news/articles/2019-08-23/bmw-mercedes-benz-are-ensnared-again-in-u-s-china-trade-war

28 Thomas Franck, "White House Directs Federal Pension Fund to Halt Investments in Chinese Stocks," CNBC, May 12, 2020. https://www.cnbc.com/2020/05/12/white-house-directs-federal-pension-fund-to-halt-investments-in-chinese-stocks.html

29 Daniel H. Rosen, Bart Carfagno, and Logan Wright, "Financial Decoupling: What Are We Really Talking About?" Rhodium Group, October 7, 2019. https://rhg.com/wp-content/uploads/2019/10/RHG_China_FinancialDecoupling_Oct2019.pdf

30 Nicolas Coeurdacier and Helene Ray, "Home Bias in Open Economy Financial Macroeconomics," NBER Working Paper No 17691, National Bureau of Economic Research, December 2011. http://www.nber.org/papers/w17691.pdf

31 Kate O'Keefe and Aruna Viswantha, "China Warns U.S. It May Detain Americans in Response to Prosecutions of Chinese Scholars," *The Wall Street Journal*, October 17, 2020. https://www.wsj.com/articles/china-warns-u-s-it-may-detain-americans-in-response-to-prosecutions-of-chinese-scholars-11602960959

so in the U.S. today, presumably activity would have reverted to trend after 12 to 18 months were it not for a hard decoupling outlook. With that working assumption, we use the 2018 figures to develop a rough number for a hard decoupling scenario on people flows.

Table 1-1: Selected Indicators of U.S. Economic Exposure to People-Flow Decoupling with China
2018 values

Indicator	Exposure
Chinese visitors to the U.S. annually	2.9 million
U.S. travel exports to China (excluding education)	$17 billion
Tuition and living expenses contributed by mainland Chinese students (undergrad and above) in the U.S.	$13.8 billion
Mainland Chinese students in the U.S. (undergrad and above)	~370,000
Mainland China share of all international students in the U.S.	33.7%
High-skilled professionals from China in the U.S. (H1B visa holders)	27,482

Sources: NAFSA: Association of International Educators, U.S. Bureau of Economic Analysis, National Travel and Tourism Office.

We focus on the two principal services export sectors—education and tourism—to estimate a near-term people-flow decoupling cost. For the 2018-2019 academic year, annual international student (undergraduate and above) spending averaged $37,200, including tuition and living expenses.[32] Average spending per Chinese visitor to the U.S. was $6,524 in 2018 (travel receipts and passenger fare, excluding education-related spending), among the highest of all visitors.[33] Continuing the rough approach taken above, if we assume that restrictions threatened to date are implemented, leading to a hard decoupling, then perhaps 50% of students and 50% of tourists from China would be diverted from the U.S. A full decoupling would entail complete elimination of these bilateral interactions. These two scenarios add between $15 billion and $30 billion a year in reduced U.S. services trade exports and international spending at home in the hard and full decoupling cases, respectively—numbers that would have gone up with time if they hadn't been arrested. In 2018, tourism had risen nearly 15%, at which rate these revenues would have doubled in less than five years.

Ideas

The cost of closing U.S.-China ideas engagement is the most difficult of the four facets we examine to put a value on, just as capturing the upside from technology diffusion in the context of liberalization is notoriously difficult. Economists attribute growth to a mix of people, money, and productivity. People and money (two of the sections above) can be measured; productivity has mostly to do, over time, with the creation and absorption of technology by society.[34]

The cost of U.S.-China decoupling in the ideas channel will show up in both the short term and the long term. Most immediately, consider the impact on net U.S. R&D outlays. The U.S. invests more in R&D than any other nation, at $511 billion in 2018 (followed by China at $452 billion, in adjusted terms).[35] Decoupling would diminish 1) U.S.

32 NAFSA: Association of International Educators, "Communities Will Suffer Economic Loss If Enrollment Declines Continue," November 18, 2019. https://www.nafsa.org/about/about-nafsa/new-nafsa-data-despite-stagnant-enrollment

33 U.S. Travel Association, "International Visitors to the US from China," 2019. https://www.ustravel.org/system/files/media_root/document/Research_Country-Profile_China.pdf

34 For an accessible recent discussion see Zia Qureshi, "Technology and the Future of Growth," Brookings Institute, February 15, 2020. https://www.brookings.edu/blog/up-front/2020/02/25/technology-and-the-future-of-growth-challenges-of-change/

35 Reported in international dollars using purchasing power parity exchange rates for comparability. OECD, "Gross Domestic Spending on R&D," 2018. https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

firms' R&D spending in the U.S. that is dependent on their operations in China, 2) Chinese R&D in the U.S., and 3) innovation spending in the U.S. by third country companies associated with their Chinese ambitions (as noted above, for fear that export or outbound investment controls might prevent them from using the fruits of their U.S. endeavors in China). Diminished R&D spending by U.S. firms is already reflected, conceptually, in the hit from U.S. FDI reduction in China described above; however, U.S. firms without an investment presence in China also invest in R&D related to China, in pursuit of export opportunities. In addition, we must consider R&D spending in the U.S. by Chinese and third country firms.

The "net" question is then whether a decoupling scenario will generate new incentives to increase R&D spending in the U.S. that exceed those reductions. Congress, the Trump administration, and the Biden campaign have all proposed very large outlays to incentivize U.S. R&D and innovation with money and policy. For instance, the proposed bipartisan Chips for America Act would provide upwards of $23 billion in potential funding and tax credits for advanced semiconductor investment over seven years;[36] President Biden has pledged $300 billion for new R&D;[37] and the Trump administration proposed to double investments in emerging industries of the future for 2021 in federal outlays on R&D.[38] If support of this magnitude actually happens, then it is reasonable to expect that the net value of U.S. R&D spending can stabilize or even increase. The concern is that it requires sustained bipartisan cooperation and hard choices. In recent years Washington has had to redirect tens of billions in subsidies to farmers and lobstermen to make up for the losses they incurred due to trade decoupling. Reprogramming Washington's attention toward innovation is a colossal challenge.

Beyond near-term R&D spending in the U.S. economic equation, the longer-term implications of decoupling for the role of ideas and innovation in the U.S. get even more difficult to tally. Each of the channels above has major innovation impacts. Even the least expansive scenario for trade decoupling is likely to continue pulling apart supply chain relationships in high technology, given mushrooming risks arising from a technology-intensive world. In investment, the fertile, global-minded financial hotbed of innovation that is the U.S. venture capital cluster is under heavy pressure to be less permissive with China. And the U.S. is talking about a blanket restriction around Chinese matriculation in U.S. science education programs, which will certainly reduce the availability of talent for recruitment into the America's high-tech industry. Finally, decoupling policies accompanied by protectionist rhetoric from some U.S. politicians has diminished the "soft power" allure of the U.S. as a beacon for ambitious innovators from around the world. All these factors must be accounted as subtracting from the U.S.' total factor productivity growth potential, although they are difficult to put a value on today.

36 Ian King, Jenny Leonard, and Laura Litvan, "U.S. Lawmakers Propose $25 Billion to Help Chip Industry," Bloomberg News, June 10, 2020. https://www.bloomberg.com/news/articles/2020-06-10/u-s-lawmakers-propose-25-billion-to-aid-semiconductor-industry?sref=H0KmZ7Wk

37 Joe Biden campaign, "The Biden Plan to Ensure the Future is 'Made in All of America' by All of America's Workers," accessed October 2020. https://joebiden.com/made-in-america/#

38 "President Trump's FY 2021 Budget Commits to Double Investments in Key Industries of the Future," Office of the White House, February 11, 2020. https://www.whitehouse.gov/briefings-statements/president-trumps-fy-2021-budget-commits-double-investments-key-industries-future/

AGGREGATE CONCLUSIONS

It is clear from this discussion that a robust accounting of aggregate costs from a hard decoupling scenario would run to the hundreds of billions of dollars annually, and a full decoupling scenario would be even more costly. Lost welfare gains from trade liberalization; shrinking export markets; written-off assets built up over decades; and disrupted U.S. jobs, investments, and expectations predicated on trillions of dollars of annual trade and investment between the world's two largest economies: these are the stakes.

Proponents of decoupling respond to the high costs associated with this course in a number of ways. They argue that the long-term economic damage from failing to confront illiberal trends in China would be even greater and thus justify the costs of decoupling. They argue that the national security benefits of decoupling also justify these costs. And they argue that replacement activity from new U.S. incentive policies or a ring-fenced like-minded market economy grouping could offset—or at least mitigate—the losses from decoupling from China. These are reasonable hypotheses, but none of them has been supported with robust analysis. Given the tremendous, long-term economic implications of the decoupling stance that has emerged over the past four years, such an economic impact assessment is crucial.

Given the analysis above and that observation, we draw four high-level conclusions:

- First, the costs of decoupling are sufficiently massive that they are likely to require a rethinking of U.S. fiscal priorities and extensive planning.
- Second, an economic impact assessment is necessary to inform decoupling policy decisions, including those tied to national security concerns, so that the relative value they create is considered.
- Third, even decoupling rooted in an objective cost-benefit analysis will result in substantial uncertainty for businesses, reducing investment, job creation, and growth in many instances.
- Finally, given these challenges, it is essential to proceed in partnership with open-market economy partners to the maximum extent possible so that general systemic uncertainty does not add to the already challenging uncertainty around U.S.-China scenarios.

The enormity of these tasks requires analysis and prioritization of strategically important industries and products. The high costs of decoupling compel us to ask what can be set aside to make the task smaller and cheaper (what we call "Green Listing"[39]), or what tools other than decoupling are available to achieve our objectives. In short, the high price tag of decoupling suggests that a more partial decoupling is better for the U.S. interest, but further cost-benefit analysis is needed to be certain. In the next section, we take the assessment down to the industry level to illuminate the direct costs, indirect impacts, and challenges to leading U.S. industries should decoupling policies proceed.

39 Agatha Kratz, Matthew Mingey, and Daniel H. Rosen, "Exploring a 'Green List' for EU-China Economic Relations," Rhodium Group, September 29, 2020. https://rhg.com/research/green-list/

Aviation Industry

INDUSTRY SNAPSHOT

A robust civil aviation industry[40] keeps the global economy humming by facilitating commerce, travel, and growth and by promoting tourism and driving innovation. Aviation refers to the activities of commercial airlines, air couriers, airports, tourism, aircraft and avionics manufacturers, and aviation R&D, but this section focuses on manufacturing. Aircraft manufacturing is inherently global, reliant on complex supply chains: one aircraft model may require hundreds of suppliers and millions of parts, from bearings to more advanced components, engines, and navigation systems. An aircraft may fly for 25 years or more, creating a significant market for maintenance, repair, and overhaul (MRO) services down the line. Cutting-edge technology is imperative for improving fuel efficiency and ensuring passenger safety but takes years to develop before an aircraft can enter production and be deployed, underscoring the importance of long-term partnerships between final assemblers of aircraft and their suppliers. Given the complex, interconnected nature of the aviation industry, even short-term decoupling can threaten long-term market participation and leadership.

The U.S. aviation industry is a leader across market segments, owing to U.S. manufacturing strength, access to global supply chains, technological sophistication, high-volume traffic, and a mature, fully liberalized market.[41] But the complexity and technological precision needed to manufacture aircraft means the industry is highly consolidated and fiercely competitive. The global market for large aircraft is effectively a duopoly: U.S. manufacturing accounted for about 43% ($82 billion) of global aircraft sales in 2018, while Europe had a 45% share.[42]

North American manufacturers accounted for more than half of the $467 billion in global commercial aircraft component[43] sales in 2019. The vast majority of this amount was attributable to U.S. firms.[44] In addition, foreign airframe manufacturers depend on U.S. components.[45] U.S. suppliers of aircraft parts sell to overseas manufacturers of complete aircraft and engines; to overseas manufacturers of components that go into aircraft or engines; and to MRO service providers.[46] For example, in 2016 U.S. content represented about 40% of the value of Airbus aircraft, 53% for the Bombardier “CSeries” jetliner, and 70% for Embraer regional jets.[47]

40 Throughout this chapter, we use the terms *civil aviation* and *commercial aviation* to refer to the industries of aircraft manufacturing, aircraft engines and parts manufacturing, other parts and equipment manufacturing, and avionics, as well as the associated services that support them, unless otherwise noted in the text.

41 Air Transport Action Group, “Aviation Benefits Beyond Borders, North American Analysis,” October 2018. https://aviationbenefits.org/media/166698/abbb18_north-america-analysis.pdf

42 The remaining market share is mostly claimed by Canadian firm Bombardier and the Russian firm Irkutz. Forbes, “How Will Boeing Gain Market Share?” February 21, 2019. https://www.forbes.com/sites/greatspeculations/2019/02/21/how-will-boeing-gain-market-share/#4793f91c1e9b

43 This figure includes engines, cabin interiors, systems, avionics, and insulation components. Grand View Research, “Aerospace Parts Manufacturing Market Size, Share and Trends Analysis Report by Product (Engine, Aircraft Manufacturing, Avionics), by End Use (Commercial, Military, Business), and Segment Forecasts, 2020-2027,” February 2020. https://www.grandviewresearch.com/industry-analysis/aerospace-parts-manufacturing-market

44 Ibid.

45 U.S. Department of Commerce, International Trade Administration, “2016 Top Markets Report, Aircraft Parts,” April 2016. https://legacy.trade.gov/topmarkets/pdf/Aircraft_Parts_Top_Markets_Report.pdf

46 Ibid.

47 Ibid.

U.S. companies also dominate the aircraft engine market, with over half of the world's commercial aircraft using engines built by U.S. companies.[48] U.S. engine and engine part manufacturers captured about 38% of global sales worth $70 billion in 2018 (including engines for military and civilian aircraft; a breakdown is not reported).[49]

Thanks to its dominant market position, the U.S. aviation industry delivers significant benefits to the U.S. economy through trade, employment, and innovation. According to the Federal Aviation Administration's (FAA's) January 2020 economic impact report, civil aviation directly contributed 2.3% of U.S. GDP, generating $850 billion in economic activity and over 4 million jobs in 2016.[50] Indirect activity such as travel arranging services and visitor spending raised the total contribution of U.S. aviation to more than 5% of GDP. The sector generates $1.8 trillion in total activity and supports nearly 11 million U.S. jobs.

In this report, we focus on aviation manufacturing. Value added from production of aircraft, engines and parts, other aircraft parts and equipment, avionics, and civilian R&D together contributed 0.83% to 2016 U.S. GDP, as shown in the gray rows in Table 2-1. Note that these figures include both primary (first-round expenditures) and secondary (follow-on inter-industry and household spending) impacts.

Table 2-1: Total Economic Impact of Civil Aviation on the U.S. Economy, 2016

IMPACTS	Output ($ bn)	Earnings ($ bn)	Jobs (Th)	Value Added (% of GDP)
Direct	**847.3**	**221.7**	**4,121**	**0.80**
Airline Operations	315.6	77	1,362	0.20
Airport Operations	81.7	26.1	542	0.40
Civilian Aircraft Manufacturing	144.4	36.2	607	0.00
Civilian Aircraft Engine and Engine Parts Manufacturing	18.6	4.5	78	0.20
Civilian Other Aircraft Parts and Equipment Manufacturing	71	17.8	331	0.10
Civilian Avionics Manufacturing	25.7	6.5	120	0.10
Civilian Research and Development	40.4	12.9	223	0.10
General Aviation Operations	52.3	12.8	226	0.10
General Aviation Aircraft Manufacturing	28.8	7.2	121	0.20
Air Couriers	68.7	20.8	512	2.30
Catalytic	**918.6**	**266.5**	**6,736**	**2.80**
Airline Visitor Expenditures	886.5	257.2	6,522	0.00
General Aviation Visitor Expenditures	11.7	3.4	86	0.10
Travel Arrangements	20.5	6	129	2.90
Total Impact	**1,765.90**	**488.2**	**10,857**	**5.20**

Source: Federal Aviation Administration, 2020. Latest available data. General Aviation refers to nonscheduled flights not operated by commercial airlines or military.

48 Daniel Longo, "IBISWorld Industry Report 33641a, Aircraft, Engine and Parts Manufacturing in the U.S.," IBISWorld, August 2017. https://sanpete.com/downloads/33641A.pdf

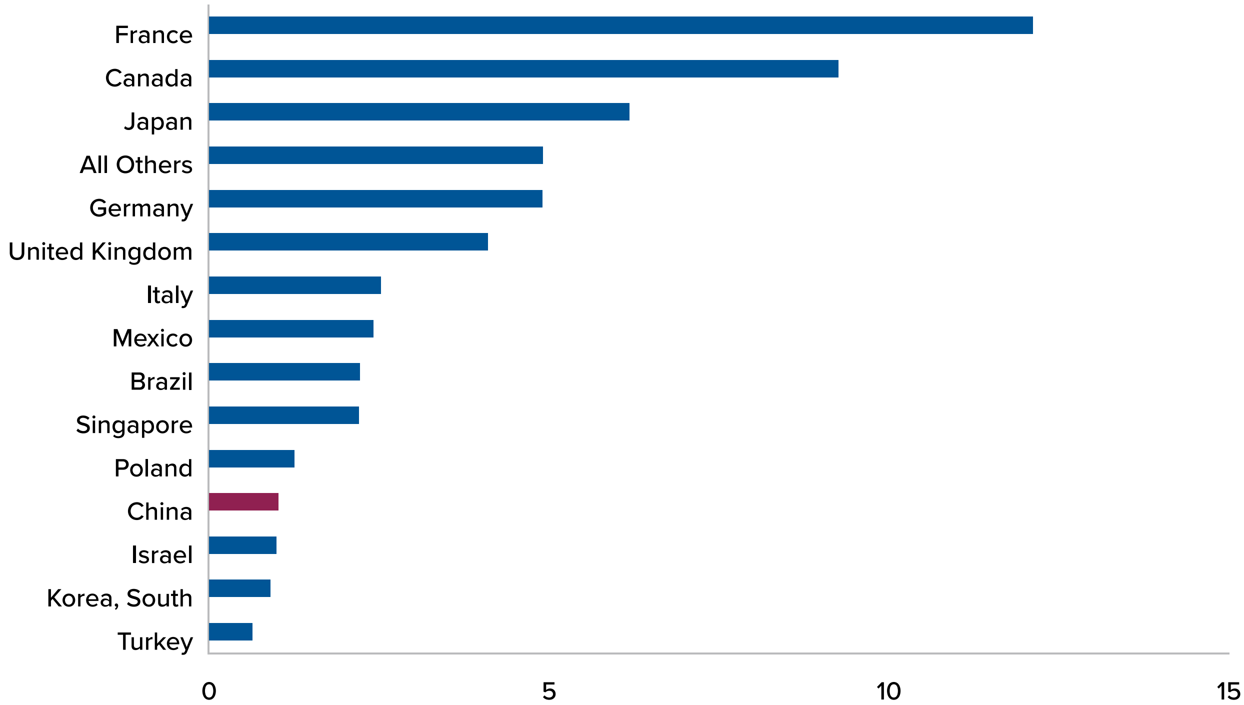
49 PR Newswire, "Aircraft Engine Market Size Worth USD 97.12 Billion by 2026; Presence of Big Giants in the Aviation Industry to Foster Growth, Says Fortune Business Insights," December 11, 2019. https://www.prnewswire.com/news-releases/aircraft-engine-market-size-worth-usd-97-12-billion-by-2026-presence-of-big-giants-in-the-aviation-industry-to-foster-growth-says-fortune-business-insights-300973239.html

50 Federal Aviation Administration, "The Economic Impact of Civil Aviation on the U.S. Economy," January 2020, p. 3. https://www.faa.gov/about/plans_reports/media/2020_jan_economic_impact_report.pdf

Aircraft manufacturing is heavily dependent on trade: exports accounted for more than half of revenue in 2017.[51] Historically, aircraft, parts, and engine manufacturing (reported as one category by the U.S. Census Bureau for data disclosure reasons) has generated the highest trade surplus of all U.S. manufacturing sectors. Exports rose to $131 billion in 2018, delivering a $90 billion surplus even as the overall U.S. trade deficit widened.[52] Ninety percent of the $130 billion in U.S. civil aviation exports are "domestic" exports, meaning their value was created in the U.S. or enhanced through domestic processing.[53] But exports alone don't capture the importance of trade and global supply chains to U.S. aviation and the economic activity it generates: global supply chains are also essential for managing costs. Figure 2-1 shows that France and Canada are top suppliers to U.S. aviation, while China ranks 11th in terms of import source as of 2018.

Figure 2-1: Top 20 Sources of U.S. Aerospace Imports, 2018

USD billion



Source: U.S. Census Bureau. Covers North American Industry Classification System (NAICS) code 3364, Aerospace products & parts.

51 IBISWorld, "Aircraft, Engine and Parts Manufacturing in the U.S," Industry Report 33641a, 2016.

52 Aerospace Industries Association, "2019 Facts and Figures: U.S. Aerospace and Defense," September 11, 2019. https://www.aia-aerospace.org/2019-facts-and-figures/

53 U.S. Census Bureau, "USATrade Online Technical Documentation," accessed December 2020. https://www.census.gov/foreign-trade/reference/guides/methodology/usatradeonline-port-tech.html

Aviation exports support U.S. jobs. In aircraft and parts manufacturing alone, the Bureau of Labor Statistics (BLS) counted 509,000 employees, while the American Community Survey conducted by the U.S. Census Bureau recorded 702,000 employees.[54] According to the BLS, the average salary for workers in the aircraft and parts manufacturing industry was $86,700, compared with the national average of around $49,000.[55] These are high-skilled jobs: aerospace engineers alone account for the biggest share of positions, at 15.5% of total jobs in the industry.[56]

R&D is a key driver of aviation industry growth that enables technological innovation. The FAA reported R&D conducted by U.S. domestic business in aircraft and parts manufacturing of around $14 billion in 2016.[57] The air transportation industry (as termed by the FAA, including manufacturers, airlines, and others) was the seventh highest industry contributor to total U.S. productivity growth despite being ranked in the bottom third in size among U.S. industries, showing its outsized impact and the importance of innovation and R&D.[58] In January 2020, the U.S. National Science Board found that the aerospace products and parts industry (including defense) ranks fifth among U.S. industries (at the 4-digit NAICS level) in R&D spending, at $26.4 billion in 2017. Of that, 45% was paid for by the companies conducting R&D, including foreign subsidiaries of U.S. companies.[59] U.S. affiliates of majority foreign-owned firms spent $7.5 billion on R&D in the transportation equipment sector in 2017 alone (an aviation breakout is not reported).[60] The industry also maintains a high R&D intensity (as a percentage of domestic net sales) of 7.5%, far above the overall manufacturing intensity of 4.7%. Moreover, U.S. R&D business expenditures by the air, spacecraft, and related machinery industry was $26.7 billion in 2016, more than three times higher than those of France, Germany, and the United Kingdom combined.[61]

Even prior to the COVID-19 outbreak, industry uncertainty after years of breakneck growth, slowing global growth, rising trade barriers, and political disputes had already pointed to an industry downturn.[62] Coronavirus has now slashed global travel. The International Air Transport Association expects traffic to decline by 48% in 2020.[63] While the COVID-19 pandemic weighs on the short-term industry outlook, the decoupling challenge will have a lasting impact.

54 Data USA, "Aircraft and Parts Manufacturing," accessed March 2020.
https://datausa.io/profile/naics/aircraft-parts-manufacturing#about

55 Data USA, "Aircraft and Parts Manufacturing," accessed March 2020.
https://datausa.io/profile/naics/aircraft-parts-manufacturing#:~:text=Average%20Salary,-%2486%2C771&text=On%20average%2C%20employees%20in%20the,total%20of%20269%20Industry%20Groups;
Aerospace Industries Association, "2019 Facts and Figures: U.S. Aerospace and Defense," September 2019.
https://www.aia-aerospace.org/wp-content/uploads/2019/09/2019-Facts-and-Figures.pdf

56 Ibid.

57 Mark Boroush, "Research and Development: U.S. Trends and International Comparisons," National Science Board, January 15, 2020.
https://ncses.nsf.gov/pubs/nsb20203

58 Federal Aviation Administration, "The Economic Impact of Civil Aviation on the U.S. Economy," November 2016.
https://www.faa.gov/air_traffic/publications/media/2016-economic-impact-report_FINAL.pdf

59 Mark Boroush, "Research and Development: U.S. Trends and International Comparisons," National Science Board, January 15, 2020.
https://ncses.nsf.gov/pubs/nsb20203

60 SelectUSA, "Foreign Direct Investment (FDI): Aerospace," November 2019.
https://www.selectusa.gov/servlet/servlet.FileDownload?file=015t0000000J2X2

61 Mark Boroush, "Research and Development: U.S. Trends and International Comparisons," National Science Board, January 15, 2020.
https://ncses.nsf.gov/pubs/nsb20203

62 KPMG, "Aviation Leaders Industry Report 2020: Steering the Supercycle," January 16, 2020.
https://assets.kpmg/content/dam/kpmg/ie/pdf/2020/01/ie-steering-the-supercycle-aviation-leaders-report-2020.pdf

63 International Air Transport Association, "IATA Updates COVID-19 Financial Impacts—Relief Measures Needed," March 5, 2020.
https://www.iata.org/en/pressroom/pr/2020-03-05-01/

U.S.-CHINA ENGAGEMENT

China is significant for the U.S. aviation business in four main ways: as a top sales market; as an MRO services market; as a growing R&D hub; and, to a lesser extent, as a source of manufacturing inputs. The relative significance of these channels of engagement vary depending on the business segment in question (e.g., aircraft, engines, parts), but all reflect lagging development in China's own civil aviation capabilities.

As the fastest-growing travel market, China is a driver of U.S. civil aviation sales revenue—both direct and indirect. China is the largest export market for U.S. aircraft, and the U.S. does not import civil aircraft, engines, or significant aircraft parts from China, according to U.S. Census data, making U.S.-China aviation trade a big contributor to the U.S. trade balance with China (official U.S. Customs data narrowly define "aircraft parts," meaning actual U.S. imports are often recorded under other trade code headings). Aviation is one of the few U.S. industries with a sizable trade surplus with China. U.S. net exports of aviation-related merchandise to China rose to a record high of $17.7 billion in 2018. In the past three years, it was the biggest single contributor of U.S. net exports to China.[64] As of 2017, China was the top revenue source for U.S. aircraft manufacturing outside the U.S., accounting for roughly 21% ($11.9 billion) of U.S. commercial aircraft sales revenue, and by extension China is probably one of the largest international destinations for many other U.S. parts manufacturers that supply the U.S. aircraft manufacturing industry.[65]

These figures mostly reflect direct sales of aircraft, parts, and engines, given the lack of competitive domestic capabilities in China (notably, U.S. exports to Ireland also mask some China-related income generated through the leasing of aircraft).[66] But U.S.-manufactured technology—notably engines, systems, avionics, and parts—also end up in Airbus planes destined for China. U.S. content accounts for 40% of the value of Airbus planes (including engines).[67] For example, the best-selling aircraft in China—the Airbus A320 and Boeing 737—are powered by engines from CFM International, a 50/50 joint venture between GE and the French company Safran, or the Pratt and Whitney division of Raytheon Technologies.[68]

In addition to selling products, U.S. companies (particularly engine makers, the largest single segment of commercial MRO spending[69]) also earn revenue from selling MRO services in China. Because aircraft and parts stay in service for decades, servicing existing aircraft and components can generate more revenues in some segments than the original product sale. For example, GE Aviation reported $19.1 billion in global services revenue in 2018, 62.4% of its total that year.[70] Manufacturers may discount the list prices of their products in order to win lucrative long-term servicing contracts with buyers.[71] Delivery of MRO services is tied to the size and location of the fleet. As such, China is the fastest-growing market

64 U.S. civil aircraft, engine, and parts exports—which is not broken out in U.S. data due to company proprietary information concerns—to China rose by an average rate of 23% annually from 2010 to 2015, accounting for 10.7% of total U.S. exports of that category over the same period. From 2016 to 2018, average annual exports to China exceeded $16 billion and rose 12% year-over-year in 2017 and 2018; however, in 2019 exports contracted by nearly half to $10.5 billion, likely owing to a mix of trade war retaliation and industry macro conditions.

65 Neil Thomas, "For Company and For Country: Boeing and US-China Relations," Macro Polo, February 26, 2019. https://macropolo.org/analysis/boeing-us-china-relations-history/

66 Xinhua, "China Contributes Most to Ireland's Aircraft Leasing Income: CSO," April 6, 2020. http://www.xinhuanet.com/english/2020-04/06/c_138950005.htm

67 U.S. Department of Commerce, International Trade Administration, "2016 Top Markets Report, Aircraft Parts," April 2016. https://legacy.trade.gov/topmarkets/pdf/Aircraft_Parts_Top_Markets_Report.pdf

68 General Electric, "GE Aviation's Presence in China Continues to Grow," November 4, 2008. https://www.geaviation.com/press-release/other-news-information/ge-aviations-presence-china-continues-grow

69 Aerospace Industry Association, "Aerospace Industry Report," October 1, 2012. https://www.aia-aerospace.org/wp-content/uploads/2016/09/AIR-2012-Book.pdf

70 Tomas Kellner, "Service Economy: New $1 Billion Deal Highlights Commercial Aviation's Asia Growth," General Aviation, November 6, 2019. https://www.ge.com/reports/service-economy-new-1-billion-deal-highlights-commercial-aviations-asia-growth/

71 AirInsight, "The Meaningless Game of List Prices," January 19, 2018. https://airinsight.com/the-meaningless-game-of-list-prices/

for MRO services: in 2018, its MRO spend totaled $7.2 billion. The Asia Pacific region, whose biggest market is China, accounted for 24% of global widebody aircraft maintenance in 2018.[72] Prior to the COVID-19 outbreak, China's MRO market was forecast to rise to $18.3 billion in the next decade—equivalent to 16% of the projected total global MRO market.[73]

U.S. firms work with Chinese firms to develop China's domestic commercial aviation industry. China has yet to develop its own viable commercial aircraft industry at scale; it remains reliant on foreign aircraft, parts, engines, and systems. China first announced its intention to develop its own commercial jetliner in a five-year industrial policy plan in 2006, and in 2008 it established the Commercial Aircraft Corporation of China (COMAC) to advance that goal. COMAC's commercial aviation program centers on two main products: the ARJ21, a regional jet similar to Canada's Bombardier, and the C919, a bigger narrow-body jetliner comparable to Boeing and Airbus models.[74] Only four ARJ-21 aircraft were in use as of 2018.[75] COMAC expected the C919 to enter production in 2021, and at the end of 2017 reported 785 pre-orders of the aircraft, though media reported that orders were nonbinding and over 90% were placed by domestic carriers.[76] Although China's aerospace industry lags considerably in productivity, output, and profitability, and China maintains the largest trade deficit in that category in the world, it ranks third in size globally, accounting for 8% of global industry activities in 2017, compared with 49% for the U.S.[77]

The MIC 2025 industrial plan set a target of having Chinese producers supply 10% of the domestic commercial aircraft manufacturing market by 2025, and 10% to 20% of the global market for regional jetliners.[78] But the C919 still has a long way to go to become commercially viable, and the timeline for its use is six years behind schedule. In addition, only half of its components are domestically produced. For example, the C919 sources engines from CFM International; landing gear from Liebherr-Aerospace in Germany; flight control systems, wheels, brakes, and navigation systems from U.S. company Honeywell; emergency power systems from U.S.-based Raytheon Technologies (formerly United Technologies); and cabin interior components from Austria's FACC.[79]

These partnerships are facilitated through joint ventures and local assets in China, but U.S. aviation sector FDI in China remains modest (Figure 2-2). Since 1990, the industry's FDI in China has totaled only $2 billion, less than 1% of total U.S. FDI in China as of mid-2019.[80] China's aviation sector is heavily restricted and dominated by the state-owned companies AVIC and COMAC. Technology transfer requirements for joint venture (JV) operations in the sector have limited U.S. FDI in China. To date, most U.S. aerospace FDI in China involves equipment such as engines, wheels, and navigation systems, as well as maintenance and servicing. Companies including Rockwell Collins and UTC maintain R&D operations in China.

72 Tom Cooper et al., "Global Fleet and MRO Market Forecast Commentary 2019–2029," Oliver Wyman, January 14, 2019, p. 38. https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2019/January/global-fleet-mro-market-forecast-commentary-2019-2029.pdf

73 Ibid.

74 Neil Thomas, "For Company and For Country: Boeing and US-China Relations," Macro Polo, February 26, 2019. https://macropolo.org/analysis/boeing-us-china-relations-history/

75 CSIS China Power, "How Is Commercial Aviation Propelling China's Economic Development?" September 26, 2018, Updated March 13, 2020. https://chinapower.csis.org/china-commercial-aviation/

76 Ibid.

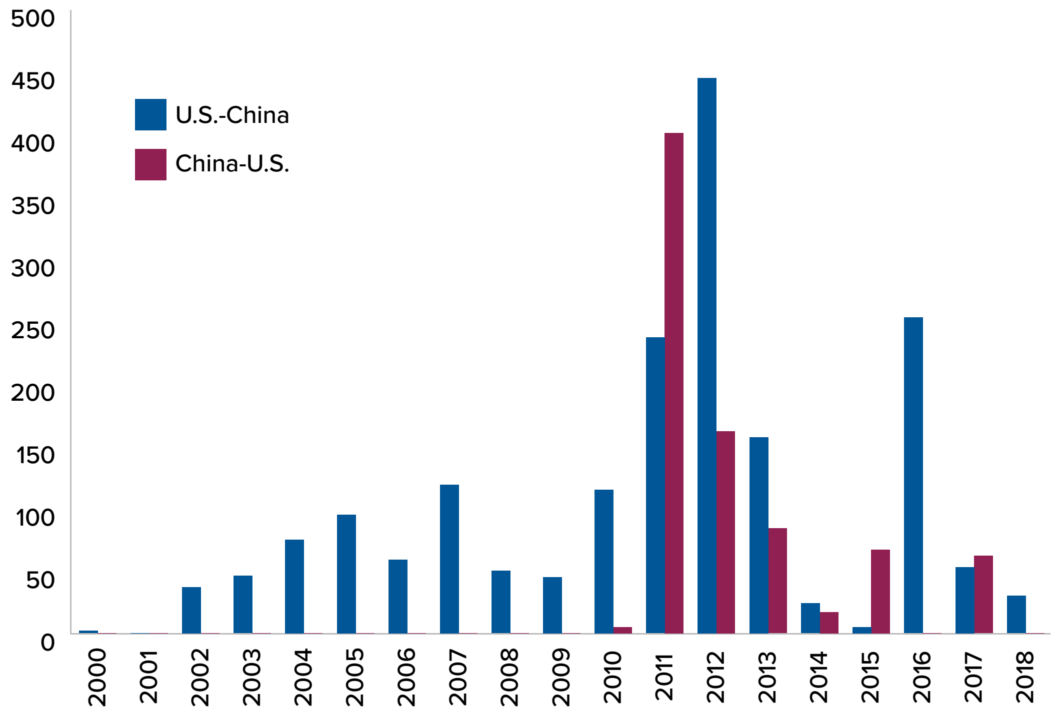
77 The term aerospace industry here refers to all in-country activities pertaining to the development, production, maintenance and support of aircraft and spacecraft. AeroDynamic Advisory & Teal Group, "The Global Aerospace Industry," July 16, 2018. https://aerodynamicadvisory.com/wp-content/uploads/2018/07/AeroDynamic-Teal_Global-Aerospace-Industry_16July2018.pdf

78 Amanda Lee, "China's Aviation Industry Has a Steep Climb to 'Made in China 2025' Goals," *South China Morning Post*, October 29, 2018. https://www.scmp.com/business/article/2170746/chinas-aviation-industry-has-steep-climb-made-china-2025-goals

79 Bloomberg, "China's Jet Challenge," March 21, 2019. https://www.bloomberg.com/quicktake/china-s-jet-challenge?sref=H0KmZ7Wk

80 Rhodium Group and National Committee on U.S.-China Relations, "The U.S.-China Investment Hub," Accessed March 2020. https://www.us-china-investment.org/

Figure 2-2: U.S.-China FDI Transactions in the Aviation Industry, 2000-2018
USD million



Source: RHG calculations.

Finally, China sources manufacturing inputs through global supply chains, both directly and indirectly. U.S. Census data indicate China accounted for 3.1% of 2018 U.S. imports of "other airplane or helicopter parts,"[81] making it the ninth largest single source—on par with Germany and South Korea (4% share each), but far behind the top U.S. supplier, Japan (25%). Public trade data do not offer granular detail into specific parts, but we deduce this category excludes propellers, rotors, undercarriages, and related parts.

The snapshot of *current* engagement does not adequately capture China's significance as a *growth* market, with enormous opportunity costs in a decoupling scenario. China is currently home to 15% of the world's commercial fleet and is expected to surpass the U.S. to become the world's largest passenger market in the coming years.[82] In 2018, Boeing forecast that revenue passenger kilometers would nearly double in a decade.[83] Air traffic within China was projected to triple from 2018 levels by 2037.[84] In September 2019, Boeing estimated that China would require about $1.3 trillion worth of new planes over the next 20 years, representing nearly 75% of demand for new single-aisle

81 Based on NAICS code 880330, reported in kilograms. A further breakdown shows China accounts for 4% of U.S. imports of "other parts of airplanes/helicopters, nesoi" (NAICS code 88033030), though a further breakdown is not reported.

82 Reuters, "Boeing Ups Forecast Chinese New Plane Purchases over 20 years by 6.2 percent," September 10, 2018. https://www.reuters.com/article/us-china-aviation-boeing/boeing-ups-forecast-chinese-new-plane-purchases-over-20-years-by-6-2-percent-idUSKCN1LR07R

83 Amanda Lee, "China's Aviation Industry Has a Steep Climb to 'Made in China 2025' Goals," October 30, 2018. https://www.scmp.com/business/article/2170746/chinas-aviation-industry-has-steep-climb-made-china-2025-goals; Jon Ostrower, "China to Overtake U.S. as Largest Air Travel Market," CNN Money, October 27, 2017. https://money.cnn.com/2017/10/27/news/china-biggest-air-travel-market-iata-forecast/index.html

84 Airbus, "China Will Need More than 7,400 New Aircraft in the Next 20 Years," November 7, 2018. https://www.airbus.com/newsroom/press-releases/en/2018/11/china-will-need-more-than-7-400-new-aircraft-in-the-next-20-year.html

aircraft and also tripling the size of its wide-body fleet.[85] According to this same analysis, China's fleet will require $1.6 trillion in commercial services over the next 20 years.[86]

But meaningful continued participation in China's aviation market growth is not a given, even for current leaders, due to competitive dynamics and industry economics. Although China's large commercial aircraft market is effectively a duopoly, U.S. suppliers are not dominant across the whole aviation industry. Even if Chinese suppliers do not yet pose a significant threat to U.S. suppliers, U.S. companies face international competition from other countries in every segment of the market, from airframes to engines to avionics. In segments with long-standing international competitors, U.S. companies must remain the preferred providers to foreign customers to maintain the global competitive edge necessary to generate the revenues needed to fund investment in new products and technologies. If motivated—or directed by Beijing—customers in China such as airlines or COMAC could shift to sourcing all their aviation needs from non-U.S. suppliers. While that substitution could not happen immediately, and would require capital investment and capacity expansion that is costly and lengthy to build out, non-U.S. competitors could justify the investment given the competitive advantage—and potential revenues—they would gain from displacing U.S. companies from the soon-to-be largest aviation market in the world.

The economics of the aviation market are unique and compound any loss of market share today into bigger losses down the line. Because aircraft, engines, and avionics systems are high-value durable goods and generate significant scale benefits (e.g., ease of training and servicing), high-value sales determine the market outlook for years after the initial sale. Whether state-owned or not, Chinese airlines are subject to significant state influence (and depend on regulatory approvals for flight and service rights). There was widespread discussion that Beijing instructed its carriers to hold off on taking delivery of new U.S. aircraft and not to place new orders, and the Chinese share of U.S. aircraft sales was halved between 2017 and 2019 as the tariff standoff continued. If Beijing leverages its influence over Chinese airlines to disadvantage U.S. suppliers—based not just on China's industrial ambitions but also due to concern that the U.S. could use export controls to disrupt Chinese production and industrial development—then U.S. companies could effectively be boxed out of the Chinese market altogether. This retaliation is not limited to slowing or stopping purchases from U.S. suppliers; it extends to delaying licenses or other forms of interference.

ANALYSIS: WHAT ARE THE COSTS?

The above snapshot establishes the leading role of U.S. companies in global aviation, their outsized contribution to the U.S. economy, and the importance of global supply chains for maintaining leadership and reaping the benefits that follow from it. These characteristics make the industry uniquely vulnerable to U.S.-China decoupling. In different segments of aviation manufacturing, U.S. firms depend on direct and indirect sales of merchandise and services to China. It takes years and millions of dollars to develop the output that is sold to China, and losing access to even a small piece of China's growing fleet would result in a loss that would last as long as equipment stays in use (decades), and would have implications for future investment.

DECOUPLING OUTCOMES

Based on interviews, we have identified the main ways in which U.S.-China decoupling threatens the aviation industry and the benefits it generates.

85 Reuters, "Boeing Raises 20-Year Forecast for China Aircraft Demand," September 17, 2019. https://www.cnbc.com/2019/09/17/boeing-raises-20-year-forecast-for-china-aircraft-demand.html

86 Ibid.

U.S. Tariffs

Aircraft, the engines that power them, and the equipment that guides them are produced through highly globalized and specialized supply chains, which means there are few options for working around higher input costs. Because the industry is so dependent on decades worth of engineering, technical expertise, and a network of trusted, compliant, regulated suppliers, disruption to that supply chain could dislodge U.S. players from global leadership positions and threaten future participation in China's growth. Section 301 trade investigation tariffs cover more than 75% of U.S. imports from China in this space, totaling more than $1 billion in 2018.[87] For specific firms and components, tariffs likely cover an even higher share.

Restrictions on U.S. Export Licenses

The U.S. government has made it increasingly difficult for U.S. businesses to obtain export licenses to sell dual-use products to Chinese customers. In addition to case-by-case changes, in June 2020 the Trump administration amended the Military End User rule that vastly expanded the range of Chinese customers that would require export licenses for their connection to Chinese military organizations.[88] In February 2020, some Trump administration officials pushed to restrict the sale of commercial jet engines made by the GE-Safran joint venture CFM International to China by withholding new export licenses for engines that had previously been licensed for export to China.[89] In the end, former President Trump questioned the wisdom of this move, and CFM was cleared in April 2020 to complete its already underway engines sales contract for the COMAC C919.

The incident highlighted the risk that the U.S. government's push to restrict the transfer of sensitive technologies with potential dual-use applications could spill over into the civilian aircraft sector, particularly if tensions between the U.S. and China escalate. Moreover, these policies create uncertainty that is difficult for U.S. firms to mitigate and incentivize Chinese customers to replace U.S. aerospace suppliers with ones from other countries.

Beijing Retaliates by Limiting Chinese Purchases from U.S. Aerospace Suppliers

The biggest decoupling scenario risk to U.S. aviation is broad Chinese retaliation to specific U.S. measures involving aviation manufacturing outlined above, or to a general deterioration in bilateral economic relations. This involves a conscious preference in China for European and other non-U.S. products. Future Chinese retaliation against the U.S. would reduce—potentially to zero—the biggest category of U.S. net exports to China. This loss would have significant downstream effects for U.S. businesses that engineer, supply, and maintain those aircraft—in the immediate production cycle and in the longer aircraft lifecycle to come.

CALCULATING COSTS

In sum, full decoupling would result in a loss of market access for U.S. suppliers in China's aerospace industry. In this section, we use two approaches to illustrate the costs of losing access to the China market. First, we look at an annual snapshot of how different segments within aviation manufacturing could lose out in terms of output, jobs, and value-added if U.S. suppliers lose access to China's market. Second, we project what those costs could be in the long term, using industry and company projections of growth in China's aircraft and related services market.

87 U.S. Census Bureau Data, RHG calculations. Products by HS 6-digit code. Tariffs effective as of February 2020. U.S. Customs classifications narrowly classify products related to aviation, in some cases to protect company information. For that reason, import values here significantly understate U.S. imports in some categories.

88 Adam Behsudi, "A Potential Game Changer for China Export Controls," Politico, April 28, 2020. https://www.politico.com/newsletters/morning-trade/2020/04/28/a-potential-game-changer-for-china-export-controls-787183

89 Ted Mann and Bob Davis, "Trump Administration Considers Halting GE Venture's Engine Deliveries to China," *The Wall Street Journal*, February 16, 2020. https://www.wsj.com/articles/trump-administration-considers-halting-ge-ventures-engine-deliveries-to-china-11581790083

Snapshot of Annual Costs

To understand what full decoupling in commercial aviation could cost the U.S. economy, we look at a snapshot of potential annual costs across subsegments of the industry—aircraft manufacturing, engine and parts manufacturing, other parts and equipment manufacturing, avionics manufacturing, and civil aviation R&D. We estimate the costs of losing all China sales revenue in these segments—the primary impact of decoupling—in terms of U.S. output and jobs, and then use FAA research to estimate secondary impacts.[90]

Assumptions

For simplicity, we make some assumptions about how loss of market access in China would reduce U.S. output of aircraft, engines, parts, avionics, and R&D spending. Decoupling would result in China reducing purchases from the U.S. and increasing purchases from Europe, causing U.S. aircraft manufacturing sales revenue and output to fall. Boeing's China revenue totaled $10.3 billion in 2016 (which we use for comparison with the FAA's 2016 data) according to its annual report. We assume that 100% of that revenue is at risk from decoupling.[91]

Getting to an estimate of how much U.S. output of commercial aviation engines, parts, and avionics would drop is less straightforward. These industry segments are more fragmented and boast more prominent players than in aircraft manufacturing. Moreover, U.S. firms that produce the valuable, complex inputs to aircraft and sell services to maintain them often engage in business and production outside the commercial aviation sphere, such as in other advanced manufacturing like construction equipment, instruments and meters, new energy equipment, and home appliances. While aviation-related activity might be their biggest business segment on financial statements, these firms' engagement with China in these activities can be significant and is typically not detailed publicly. For illustrative purposes, we consider the costs of a 10% and a 20% reduction in output from these U.S. industries as a proxy for lost China sales, assuming that between 10% and 20% of U.S. global sales are absorbed by China. We base this range on available financial data from a small sample of firms that report China or Asia Pacific revenue, but ultimately these assumptions are stylized.[92]

Finally, companies use revenues from sales to fund R&D expenditures. R&D intensity is measured as a ratio of R&D spend to sales. Based on Boeing's R&D spending-to-earnings ratio, we assume civilian aircraft R&D intensity of 4.9%. In other words, $1 in sales generated $0.05 in R&D spending in civilian aircraft manufacturing. In our estimation of decoupling costs, we downgrade R&D in commercial aviation manufacturing, engine manufacturing, and avionics segments by this ratio.

90 See methodology appendix for details.

91 Exports accounted for over half of U.S. aircraft manufacturing revenues in 2017; that figure is likely higher for Boeing's China revenues, so we use 75% as an estimate of revenue lost from losing market access in China.

92 For example, Bloomberg reports financial data by geographic segment for a small sample of top U.S. firms, typically with a breakout for Asia Pacific but not for China (depending on the company). For two engine manufacturers, the Asia Pacific region accounted for around 13% of sales revenue in 2018. For several companies in the aircraft systems and aircraft components industries, Asia Pacific revenues accounted for 10% to 25%. GE's China revenues were $8.1 billion, accounting for around 7% of total revenues in 2015. GE's China business includes power sector, commercial aviation, health care, energy and renewables, oil and gas, transportation, and more. General Electric, "GE in China Factsheet, October 2016.
https://www.ge.com/cn/sites/www.ge.com.cn/files/GE_in_China_fact_sheet_EN_0811.pdf

Calculating the Costs

We can think of U.S. revenue losses due to lost China market access as the *primary impacts* of decoupling—a term used to describe the dollar amounts flowing through the civil aviation manufacturing industry, reflecting the sum of revenues from sales of goods and services.[93] But what are the *secondary impacts*—or effects on industries that supply civil aviation manufacturing, and on the spending of people employed in that industry? We use multipliers published by the FAA to estimate the economy-wide costs from lost China revenue.[94]

Table 2-2 shows that lost U.S. sales revenue from losing China market access would result in a U.S. output loss ranging from $38 billion to $51 billion, depending on our 10% to 20% stylized shortfall of sales revenue for engines, avionics, and parts manufacturers. The U.S. job losses associated with this reduction range from 167,000 to 225,000. The lost sales from these stylized projections would reduce R&D spending by $1 billion to $2 billion. These estimated costs are not precise, and they assume relationships between direct and indirect spending in the economy do not change, but they do offer a reasonable scope for contextualizing a snapshot of the costs across industry segments.

Table 2-2: Estimated Annual Costs of U.S.-China Commercial Aviation Decoupling
Output USD billion (2016); jobs in thousand workers

Industry Segment	Output ($ Bn)	Jobs (Th)
Civilian Aircraft Manufacturing	-25.6	-107.8
Civilian Aircraft Engine and Engine Parts Manufacturing	-1.9 to -3.7	- 7.8 to -15.6
Civilian Other Aircraft Parts and Equipment Manufacturing	- 7.2 to -14.2	-33.1 to -66.2
Civilian Avionics Manufacturing	- 2.6 to -5.1	- 12.0 to -24
Civilian Research and Development	-1.1 to -2.1	-5.9 to -11.7
Subtotal: Civil Aviation Manufacturing	**-38 to -51**	**-167 to -225**
Percentage loss	**-12.7% to -16.90%**	**-14.7% to -16.6%**

Source: Federal Aviation Administration, 2020; RHG calculations.

Extending Forward: How to Think about Longer-Term Costs

Given the long production cycles and lifespans of aircraft and components, the loss of sales today means sacrificing future market share and aftermarket services revenues tied to those sales for many years to come. In this section, we offer a simplified look at the price that U.S. firms stand to pay if they are boxed out of China's growing commercial aviation market in the next 10 to 20 years.

93 We assume a reduction in sales revenue is equivalent to a reduction in primary output. Federal Aviation Administration, "The Economic Impact of Civil Aviation on the U.S. Economy," November 2016.
https://www.faa.gov/air_traffic/publications/media/2016-economic-impact-report_FINAL.pdf

94 We combine this decoupling shock with the FAA's work to surmise what a reduction in U.S. aviation industry output would equate to in terms of jobs and output. A number of assumptions hold. First, we assume static relationships between variables, meaning that, for example, the relationship between primary output and total output, jobs, and value-added remain constant. Decomposing the FAA's 2020 report, we derive multipliers that capture the relationship between primary output (treated as equivalent to sales) and total output, earnings, and jobs, and use them to calculate the total economic activity that would be impacted. In the FAA's nomenclature, *primary output* refers to first-round expenditures resulting from the sale of goods and services produced (including both directly and through supply chains), while *total output* adds follow-on spending supported by primary output further down supply chains—spending by employees, spending by suppliers of suppliers, and other spending derivative of first-round expenditures. See methodology appendix for details.Federal Aviation Administration, "The Economic Impact of Civil Aviation on the U.S. Economy," November 2016.
https://www.faa.gov/air_traffic/publications/media/2016-economic-impact-report_FINAL.pdf

Methodology and Assumptions

China is projected to become the world's largest air travel market in a matter of years. Taking pre-COVID growth projections for China's fleet and MRO spend growth as a baseline, we calculate the value of the U.S. loss of market share in China's expanding fleet, and the value of lost U.S. market share in China's MRO market, over a 10-year and 20-year time horizon. We make a number of assumptions to simplify this thought experiment:

- We assume the breakdown of market share for aircraft in China as: 45% (U.S.), 45% (Europe), 10% (domestic competitors). To simulate decoupling, we calculate the cost of the U.S. market share falling to zero.
- We calculate the potential revenue lost each year based on additions to China's fleet—that is, newly purchased fleet each year.
- We use $160 million as the average price per aircraft to calculate a dollar value of projected new aircraft deliveries each year, based on Boeing's projected China market value for new aircraft.
- We assume U.S. companies hold 33% of China's MRO market. There is no single credible estimate of China's MRO market share held by U.S. firms, as the market is fragmented and evolving, so we draw on the following figures:
    - Foreign companies complete 65% of MRO services in China.[95]
    - Officially, of the 859 MRO firms in China, 467 are Chinese and 392 are foreign, of which U.S. firms number 193.[96]
    - If we assume market share is proportionate to the number of companies active in the market, we can infer that U.S. firms hold 33%. This may undercount non-MRO firms that provide MRO services.

Decade of Decoupling: $277.2 Billion in Forgone Deliveries

China's fleet is projected to more than double over the next decade, making it an enormous market that U.S. suppliers cannot afford to miss out on. Industry consultancy Oliver Wyman projects that China's fleet will expand by 7.9%, on average, from 2019 to 2029, an increase of 3,833 planes to 7,209 total, with the fleet expanding faster (9.6%) in the first five years compared with the last five years (6.2%).[97] That means an annual increase of 383 new aircraft per year, averaged over the decade ahead.

We can think of the direct cost of full decoupling for aircraft manufacturers as the opportunity cost of losing future U.S. market share in China. The U.S. 45% market share equates to 146 of 324 new aircraft deliveries to China in year one (projected for 2020), equivalent to $23.4 billion based on list prices. As China's fleet is projected to grow at a faster pace in the first half of the decade, the U.S. projected annual market share would peak in 2024, at $33.8 billion, and average $31.9 billion per year from 2020 to 2029. Those annual losses add up to $277.2 billion in forgone revenues by 2029 should China stop buying U.S. planes in the decade ahead.

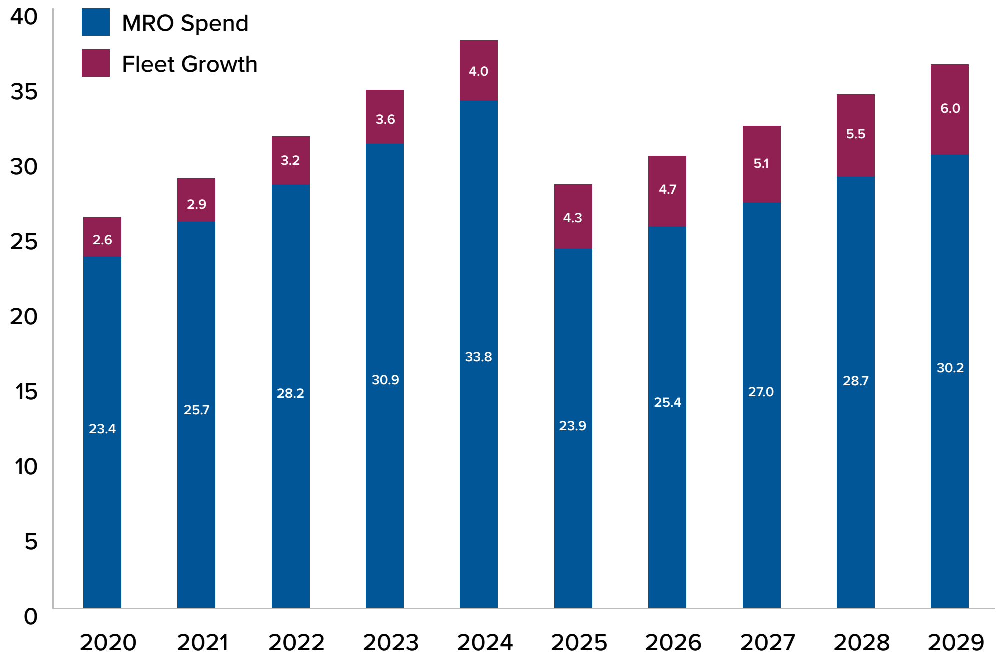
95 Qianzhan Research Institute, "Foreseeing 2019: Complete Roadmap of China's Aviation Industry in 2019," March 2019. https://zhuanlan.zhihu.com/p/59098485

96 Ibid.

97 Tom Cooper et al. "Global Fleet and MRO Market Forecast Commentary 2019–2029, Oliver Wyman, January 14, 2019, p. 38. https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2019/January/global-fleet-mro-market-forecast-commentary-2019-2029.pdf

Potential U.S. losses do not stop at U.S. aircraft manufacturing if decoupling escalates. China is also the fastest-growing market for MRO services. Its annual MRO spend is forecast to rise from $7.2 billion in 2018 to $18.3 billion in the following decade—equivalent to 16% of the projected total global MRO market.[98] Without an authoritative estimate, we assume U.S. firms hold a 33% market share in China's MRO market, as described above. If China's MRO market grows to $18.3 billion by 2029, forgone U.S. market share of 33% would rise from $2.6 billion in year one to $6 billion in 2029, assuming equivalent loss of market share each year (Figure 2-3). That cost disproportionally accrues to U.S. engine manufacturers: MRO industry forecasts show engine MRO is the biggest component of China's MRO spending (compared with airframes, components, and lines), and engine MRO spend is slated to rise from 30% of China's total MRO spend in 2019 to 40% (or $7.3 billion) by 2029.

Figure 2-3: Estimated Annual Value of U.S. Market Share of China's Fleet Growth and MRO Spend
USD billion



Source: Oliver Wyman, 2019; RHG calculations. MRO spend is equivalent to one-third of annual market size. Fleet growth is marginal.

Rather than an analysis of the relationships between all relevant variables, these estimations reflect the dollar value of opportunity cost from U.S. firms losing all access to China's market. We focus on aircraft and MRO services sales for this decade calculation, as we have more granular projections of annual changes in China's market size; in the 20-year calculation below, we add the cost of total commercial services related to commercial aviation, which are projected to grow substantially over that period.

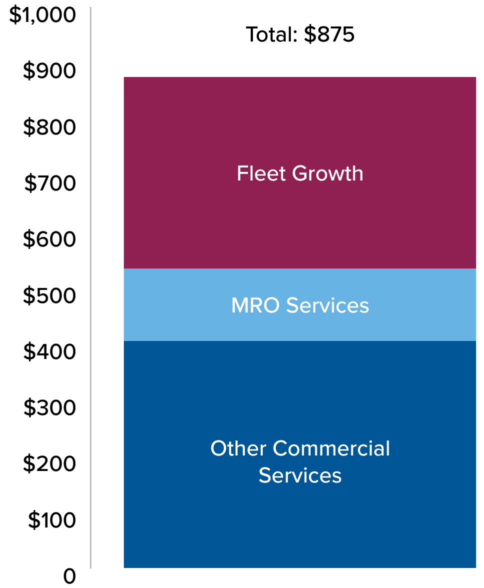
98 Ibid.

Jumping Forward: Lost Aircraft and Commercial Services Sales 20 Years Out

We extend our 10-year cost estimate forward to 2038 to look at longer-term costs. Boeing estimates China's commercial airplane market will grow 4.5% to $1.3 trillion from 2019 to 2038, and China's market for commercial services—including corporate services; marketing, planning, and customer service; flight operations; MRO; and ground, station, and cargo operations—will grow 5.7% to $1.6 trillion over the same time frame.[99] Extending our cost estimate to cover more than just MRO services is more representative of the opportunity cost for U.S. providers, but less concrete for a number of reasons. The aviation commercial services market is fragmented across a diverse range of suppliers. In addition, commercial services are loosely defined and still evolving with new technologies and service types. Further, original equipment manufacturers (OEMs) are increasingly seeking to enter the field given high margins and strong aftermarket services demand. Because there is no credible estimate of U.S. market share over the next 20 years in these services segments, we use the 33% U.S. share of China's MRO market assumption as a reference point for extending forward to understand the upward bound of what U.S. firms doing business in China's commercial aviation industry could stand to lose.

Using Boeing's projections for fleet and commercial service growth in China through 2038, we back-calculate the value of the U.S.' cumulative lost market share—or the cumulative value of the U.S.' 45% market share of new deliveries over that period—and add in the value of our assumed 33% U.S. market share of all commercial aviation services in China. If China's fleet expands by around 5,000 aircraft as projected by Boeing, a constant 45% U.S. market share would result in deliveries of 2,100 U.S. aircraft from 2020 to 2038, valued at $342 billion. Figure 2-4 shows that the opportunity cost of shutting the U.S. out of China's market growth under these assumptions totals $875 billion over the 2020-2038 period. Although the commercial services loss can be thought of as an upper bound, this accounting underestimates other costs outside the scope of this analysis, such as lost revenues derived from Beijing's decision to exclude less visible U.S. manufacturers and service providers from any activities within China.

Figure 2-4: Estimated Cumulative Value of Lost U.S. Market Share in China's Fleet and Commercial Service Spend Growth, 2020-2038
USD billion



Sources: Boeing, "Commercial Market Outlook, 2019-2038"; Oliver Wyman, 2019; RHG calculations.

99 Boeing, "Commercial Market Outlook, 2018-2019," September 2019.
http://www.boeing.com/resources/boeingdotcom/commercial/market/commercial-market-outlook/assets/downloads/cmo-sept-2019-report-final.pdf

Long-term losses from U.S.-China decoupling are not just bilateral. If the U.S. loses access to China's aviation market, U.S. producers will have fewer sales over which they can amortize costs, so the cost of American products will rise. That will both shrink the U.S. share of the global market and lead to increased aviation costs in the domestic market, hurting U.S. travelers, U.S. airlines, and suppliers up and down the value chain. Moreover, with sales revenue supporting R&D spending, shrinking U.S. market share will ultimately hurt long-term U.S. industry leadership. Although industry-wide (aerospace products and parts—NAICS 3364) R&D intensity is 7.5%, the ratio is lower at 3.4% if we account only for R&D spending paid for by Boeing alone.[100] Even at the lower end of the range, the projected forgone $875 billion in sales over 20 years translates to a cumulative $29.7 billion gap in projected R&D spending, or $1.5 billion per year on average. At the high end of R&D intensity, the cumulative 20-year loss is $65.9 billion (assuming intensity remains constant), or $3.3 billion per year on average.

INTERPRETATION: WHAT DOES IT MEAN FOR THE U.S. ECONOMY?

For aviation, U.S.-China decoupling would, at a minimum, mean reduced aircraft sales to China, resulting in lower U.S. manufacturing output, slimmer revenues for the firms involved, and consequently U.S. job losses and reduced R&D spending—leading to a longer-term reduction in U.S. competitiveness. Each of these elements impacts U.S. competitiveness in a sector where competition is already intense. Although China continues to lag U.S. and other international competitors in efficiency, productivity, cost, and innovation in aviation, Beijing is determined to build China's capacity. It is not far-fetched that China may become a global supplier of aircraft—Airbus is a prime example, transforming from a fledgling startup in the 1970s to an industry leader today. By decoupling, U.S. aviation firms would lose the opportunity to enjoy benefits from COMAC's potential growth. But China cannot produce most of the components of the C919 by itself; if U.S. companies can't take advantage of COMAC's growth, non-U.S. companies will. The cost of diminishing gains from U.S. leadership in aviation places at risk one of the biggest contributors to overall U.S. productivity growth.

Moreover, U.S.-China decoupling in aviation would generate *unilateral U.S. losses to the benefit of competitors, including China's own domestic industry*. Fewer sales for U.S. aviation companies to fund investment in new technologies translates into more revenues for non-U.S. competitors, which can use that money to develop new aviation products and platforms to outcompete the U.S. industry globally. U.S. government aerospace R&D spending has been declining for years, while non-U.S. competitors including China have been ramping up R&D spending.[101] Losing the funding derived from a global leadership position and sales puts a burden on U.S. companies to cut R&D spending, compounding market share losses and eroding over time the competitive advantage that U.S. companies enjoy.

Decoupling risks to U.S. leadership in advanced aviation technologies are not hypothetical. The extreme negative impact of denying U.S. engine manufacturers export licenses was averted, at least temporarily, after media reports caught former President Trump's attention. Ultimately, the decision to grant a license to CFM was strong acknowledgment of the difference between civilian technologies and those with military or dual-use applications; however, U.S. companies and their business partners cannot always rely on last-minute tweets from the president to rescue them. Although the outcome was positive in this case, the political-industry consultation process was neither predictable, reliable, nor inclusive, and it left industry scrambling. The threat of blunt export controls looms.[102] Unpredictable policy makes U.S. aircraft, engines, equipment, manufacturers, and suppliers unreliable business partners in an industry that is built on long-term global partnerships. It would not be a surprise to see partners looking for global supply chain alternatives to the U.S. in order to mitigate political risks.

100 Mark Boroush, "Research and Development: U.S. Trends and International Comparisons," National Science Board, January 15, 2020. https://ncses.nsf.gov/pubs/nsb20203

101 Aerospace Industries Association, "2019 Facts and Figures," September 2019. https://www.aia-aerospace.org/wp-content/uploads/2019/09/2019-Facts-and-Figures.pdf

102 U.S. Department of Commerce, Bureau of Industry and Security, "Expansion of Export, Reexport, and Transfer (in-Country) Controls for Military End Use or Military End Users in the People's Republic of China, Russia, or Venezuela," April 28, 2020. https://s3.amazonaws.com/public-inspection.federalregister.gov/2020-07241.pdf

Far from bolstering U.S. competitiveness, this outcome directly controverts a national security argument for decoupling from China's aviation industry, by sacrificing revenues for R&D spending, resulting in fewer spin-off defense technologies for U.S. national security. Minimizing decoupling costs while maximizing the U.S. national interest likely involves a combination of retaining access to China's domestic market to continue to generate sales revenue from the soon-to-be largest aviation market in the world, while continuing to narrowly define export controls so the U.S. isn't at a disadvantage to competitors. Advanced technologies funded by revenue reinvested in R&D keep U.S. companies at the cutting edge—not just in commercial segments, but in aerospace technologies also used for defense products.[103]

Semiconductor Industry

INDUSTRY SNAPSHOT

Semiconductors are ubiquitous: they are essential components in everyday items, from computers and phones to cars and refrigerators, and are crucial for the development of next-generation technologies like artificial intelligence, quantum computing, and 5G. Semiconductors are sophisticated devices produced through highly specialized global supply chains. Firms in the semiconductor industry are categorized by where they are situated in this supply chain, specializing either in design, manufacturing, assembly, testing, or packaging activities, in addition to the associated upstream materials, software, and equipment firms.[104] Completed and assembled chips are sold to OEMs that assemble them into final products, which are then shipped on to retailers and consumers. Vertically integrated semiconductor companies—known as integrated device manufacturers—perform all production steps in-house.

The increasing complexity and costs involved in manufacturing leading-edge semiconductors present a steep barrier to entry, leading to a consolidated industry dominated by a few players. The top five semiconductor suppliers earned 42.1% of the $418.3 billion in global chip sales revenue in 2019.[105]

As it stands, the U.S. is *the* global leader in terms of sales, profits, and innovation. It is home to seven of the world's 15 largest semiconductor firms, accounting for 55% of global sales in 2019, far larger than any other country.[106] U.S. firms maintain the biggest market share in every major region in the world.[107]

At the same time, U.S. firms do not lead in every segment. In areas such as contract semiconductor manufacturing and assembly and testing, U.S. firms rely almost exclusively on Asian-based supply chains. And while semiconductors are the fifth largest U.S. export, the U.S. today accounts for only 12% of global chip production, down from 37% in 1990 and projected to decline further.

The U.S. leading position fuels a virtuous cycle of R&D spending to maintain technological superiority, which in turn leads to higher market share and higher profit margins that enable more R&D investment.[108] The race to develop

103 World Trade Organization, "WTO Panel Issues Report Regarding U.S. Tariffs on Chinese Goods," September 15, 2020. https://www.wto.org/english/news_e/news20_e/543r_e.htm

104 John VerWey, "The Health and Competitiveness of the U.S. Semiconductor Manufacturing Equipment Industry," U.S. International Trade Commission, July 2019. https://www.usitc.gov/publications/332/working_papers/id_058_the_health_and_competitiveness_of_the_sme_industry_final_070219checked.pdf

105 Gartner, "Gartner Says Worldwide Semiconductor Revenue Declined 11.9% in 2019," January 14, 2020. https://www.gartner.com/en/newsroom/press-releases/2020-01-14-gartner-says-worldwide-semiconductor-revenue-declined-11-point-9-percent-in-2019

106 Barbara Jorgensen, "U.S. IC Companies Maintain Global Market Share Lead," EE Times, March 20, 2020. https://www.eetimes.com/u-s-ic-companies-maintain-global-marketshare-lead/

107 Semiconductor Industry Association, "2020 Factbook," April 21, 2020. https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

108 Antonio Varas and Raj Varadarajan, "How Restricting Trade with China Could End US Semiconductor Leadership," Boston Consulting Group, p. 10, March 9, 2020. https://www.bcg.com/publications/2020/restricting-trade-with-china-could-end-united-states-semiconductor-leadership.aspx

ever-smaller chips to power smaller electronic devices has made staying competitive exponentially more expensive, requiring semiconductor firms to make huge investments in both capital equipment and R&D.[109] The U.S. semiconductor industry spends more on R&D than does any other country's semiconductor industry, giving it a comparative advantage in chip design and process technology, which accounts for about 45% of a semiconductor's value.[110] The cost of a state-of-the-art chip manufacturing facility (known as a "fab"), for example, is at least $10 billion.[111] U.S. industry typically spends between 15% and 20% of its annual revenue on R&D—about $40 billion in 2019—the second highest rate among major U.S. manufacturing sectors and over three and a half times the amount invested in 1999.[112]

This virtuous cycle brings economic and security benefits to the U.S. as a whole. The semiconductor industry alone contributed 2% of total U.S. manufacturing value-added, totaling $53.4 billion in 2018 and ranking 15th among 86 U.S. industries.[113] Value-added represents an industry's contribution to overall GDP, making semiconductors an industry critical to U.S. growth.[114] In addition, U.S. leadership in semiconductors is closely associated with national security. Advanced military systems depend on innovations in chip technology, and the cybersecurity of critical infrastructure cannot be strengthened without secure semiconductors.

Overseas sales fund large capital investments like manufacturing and advanced research facilities as well as capital equipment purchases. The semiconductor industry has the 10th highest net capital expenditure-to-sales ratio (spending on new capital as opposed to replacing the old) in the U.S.—exceeded only by other capital-intensive industries like utilities and trucking.[115] U.S. semiconductor firms maintain about 44% of their manufacturing capacity inside the U.S. as of 2019.[116] U.S. semiconductor firms invest abroad as well to locate closer to their customers and take advantage of government incentives not offered in the U.S. In 2019, about 58% ($24 billion) of U.S. exports and 58% ($16 billion) of U.S. imports of semiconductors and related devices were from U.S. parents to and from their majority-owned foreign affiliates (MOFAs).[117]

Innovative spending stimulates growth by allowing employees to do more with less, which creates high-paying jobs. The industry directly employs about 250,000 workers in the U.S. and indirectly supports an additional 1 million jobs.[118] Labor productivity in the U.S. semiconductor sector has grown by an average of 5.1% per year from 2007 to

109 Alex Capri, "US-China Tech War and Semiconductors," Hinrich Foundation, January 2020.
https://hinrichfoundation.com/trade-research/global-trade-research/thought-leadership/semiconductors-at-the-heart-of-the-us-china-tech-war/

110 Semiconductor Industry Association, "2020 Factbook," April 21, 2020.
https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

111 Alex Capri, "US-China Tech War and Semiconductors," Hinrich Foundation, January 2020.
https://hinrichfoundation.com/trade-research/global-trade-research/thought-leadership/semiconductors-at-the-heart-of-the-us-china-tech-war/

112 Semiconductor Industry Association, "Winning the Future. A Blueprint for Sustained U.S. Leadership in Semiconductor Technology," April 2019.
https://www.semiconductors.org/wp-content/uploads/2019/04/FINAL-SIA-Blueprint-for-web.pdf;
Semiconductor Industry Association, "2020 Factbook," April 21, 2020.
https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

113 U.S. Department of Commerce, Census Bureau, "2018 Annual Survey of Manufacturers," April 2020.
https://www.census.gov/programs-surveys/asm/data/tables.html

114 U.S. Department of Commerce, Bureau of Economic Analysis, "Glossary," accessed June 2020.
https://www.bea.gov/help/glossary?title_1=All&title=value

115 Aswath Damodaran, "Capital Expenditures by Sector (US)," New York University, January 2020.
http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/capex.html

116 Semiconductor Industry Association, "2020 Factbook," April 21, 2020.
https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

117 The data considers trade imports and exports under the NAICS code 334413. U.S. Department of Commerce, U.S. Census Bureau, "Related Party Trade Database," accessed July 2020.
https://relatedparty.ftd.census.gov/

118 Semiconductor Industry Association, "2020 Factbook," April 21, 2020.
https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

2019, while total U.S. productivity grew by only 1.4%.[119] Given the high skill required, industry wages are roughly 30% higher than the national average.[120]

U.S.-CHINA ENGAGEMENT

China is an inextricable link in the semiconductor industry value chain, and much of the activity that enables U.S. leadership in production, capital investment, R&D, and jobs involves China. The U.S. engages with China in the semiconductor industry through three main channels: foremost as a sales market for semiconductors or related technology; as a source of components and assemblies for U.S. manufacturers; and to a lesser extent as a base for manufacturing and assembly. U.S. firms conduct the majority of R&D work—the most value-intensive part of the chip production process—where they are headquartered, with a minor share conducted in China.

China is the world's largest single-country market for semiconductors due to its role as a key manufacturing and assembly hub for electronics containing semiconductor technology. As of 2018, factories in China produced close to 90% of the world's smartphones, 65% of personal computers, and 67% of smart televisions, and exported electronic goods containing semiconductors worth $600 billion in 2017.[121] This productivity has enabled China's integrated circuit (IC) imports to rise by around 10% annually in volume terms from 2015 to 2018, according to China Customs data. Even as imports slowed in 2019 under trade war pressures, China imported 443.3 trillion integrated circuits from the world that year, and that figure has risen to around 500 trillion units in the first half of 2020.

China is also the world's largest market for consumer electronics, accounting for 40% of global demand for mobile phones, 30% for consumer appliances, and 43% of electric vehicles.[122] As a result, more than half of the global semiconductor supply crosses China's borders.[123] Despite China's role as a key manufacturing hub for all global electronics, China still relies on imported foreign technology, with Chinese semiconductor companies supplying only 14% of demand from Chinese OEMs in value terms.[124]

These characteristics make China a huge source of intermediate and final demand for U.S. semiconductor firms.[125] The U.S. exported $8.1 billion in integrated circuits to China in 2019, resulting in a $6.5 billion U.S. trade surplus in

119 BLS is measuring by production, while SIA is measuring by sales. U.S. Department of Labor, Bureau of Labor Statistics, "Labor Productivity and Costs," March 5, 2020. https://www.bls.gov/lpc/prodybar.htm;
Semiconductor Industry Association, "2020 Factbook," April 21, 2020.
https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

120 Semiconductor Industry Association, "2019 Databook," July 2019.
https://www.semiconductors.org/data-resources/market-data/sia-databook/

121 John VerWey, "Chinese Semiconductor Industrial Policy: Past and Present," U.S. International Trade Commission, July 2019.
https://www.usitc.gov/publications/332/journals/chinese_semiconductor_industrial_policy_past_and_present_jice_july_2019.pdf;
Semiconductor Industry Association, "Submission of the Semiconductor Industry Association Regarding Proposed Determination of Action Pursuant to Section 301: China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation," July 20, 2018.
https://www.semiconductors.org/wp-content/uploads/2018/08/Final-_SIA_Submission_on_301_Tariffs.pdf

122 Mckinsey Global Institute, "China and the World," July 2019.
https://www.mckinsey.com/~/media/mckinsey/featured%20insights/china/china%20and%20the%20world%20inside%20the%20dynamics%20of%20a%20changing%20relationship/mgi-china-and-the-world-full-report-june-2019-vf.ashx

123 Li Tao, "How China's 'Big Fund' Is Helping the Country Catch up in the Global Semiconductor Race," South China Morning Post, May 10, 2018.
https://www.scmp.com/tech/enterprises/article/2145422/how-chinas-big-fund-helping-country-catch-global-semiconductor-race;
Matthew Fulco, "Taiwan, Still a Semiconductor Success Story," The New Lens, September 14, 2018.
https://international.thenewslens.com/article/104177

124 Antonio Varas and Raj Varadarajan, "How Restricting Trade with China Could End US Semiconductor Leadership," Boston Consulting Group, p. 10, March 9, 2020.
https://www.bcg.com/publications/2020/restricting-trade-with-china-could-end-united-states-semiconductor-leadership.aspx

125 Alex Capri, "US-China Tech War and Semiconductors," Hinrich Foundation, January 2020.
https://hinrichfoundation.com/trade-research/global-trade-research/thought-leadership/semiconductors-at-the-heart-of-the-us-china-tech-war/

that product category.[126] As leading designers and manufacturers of semiconductors, U.S. firms sell chips and related intellectual property to Chinese OEMs directly and through third countries. China-based firms purchased $70.5 billion worth of U.S. semiconductors in 2019, about 36.6% of U.S. firms' global sales.[127] Sales revenue data capture activities like chip design, intellectual property licensing, sales through third countries, and sales to U.S. foreign subsidiaries that may not be captured by trade data.[128] U.S. firms also outsource low value-added, labor-intensive activity like assembly, testing, and packaging (ATP) of semiconductors to their MOFAs. China is home to about 12% of the global ATP market by value.[129] As a result of this globalized supply chain, the U.S. also imports semiconductor-related goods from China, which accounted for 21% of total U.S. semiconductor-related imports from the world in 2018 in value terms (Table 3-1).

Table 3-1: U.S. Semiconductor Imports from China and Share of World Imports, 2018
USD million

Product	Imports from China	Imports from World	China Share
Semiconductors and Related Devices	4,817	44,256	11%
Semiconductor Machinery	4,610	14,013	33%
Other Electronic Components	3,157	6,844	46%
Capacitors, Resistors, Coils, and Transformers	1,227	4,959	25%
Printed Circuits	1,000	2,127	47%
Electronic Connectors, Including Parts	635	2,597	24%
Total	**15,446**	**74,796**	**21%**

Source: USA Trade Online. By NAICS code.

To a far lesser extent, U.S. sales and exports to China are facilitated by capital investment there. From 1990 through 2018, U.S. semiconductor firms invested a total of $21 billion in China.[130] This is a relatively small number, as U.S. capital expenditure (capex) in China represents an average of only 7.7% of its global capex from 2009 to 2017.[131] Earlier flows were mainly greenfield and lower-value add investments to set up foreign subsidiaries. Some U.S. firms use contract chip manufacturing services in China as well, activities that are not reflected in investment totals. In addition, U.S. companies have made numerous non-greenfield strategic investments such as acquisitions of local tech firms, newly established joint ventures, and venture capital investments.

126 U.S. Census Bureau. Based on HS 8542, electronic integrated circuits, micro assemblies, and parts.

127 Alex Capri, "US-China Tech War and Semiconductors," Hinrich Foundation, January 2020.
https://hinrichfoundation.com/trade-research/global-trade-research/thought-leadership/semiconductors-at-the-heart-of-the-us-china-tech-war/;
Semiconductor Industry Association, "2020 Factbook," April 21, 2020.
https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

128 This takes into account U.S.-based R&D, creation of intellectual property, design, and other high value-added work. SelectUSA, "Semiconductors Spotlight," accessed June 2020.
https://www.selectusa.gov/semiconductors-industry-united-states

129 Alex Capri, "US-China Tech War and Semiconductors," Hinrich Foundation, January 2020.
https://hinrichfoundation.com/trade-research/global-trade-research/thought-leadership/semiconductors-at-the-heart-of-the-us-china-tech-war/

130 Rhodium Group and National Committee on U.S.-China Relations, "The U.S.–China Investment Hub," accessed June 2020.
https://www.us-china-investment.org/

131 Devi Keller, Jimmy Goodrich, Zhi Su, and Rhodium Group, "The U.S. Should Be Concerned with Its Declining Share of Chip Manufacturing, Not the Tiny Fraction of U.S. Chips Made in China," Semiconductor Industry Association, July 10, 2020.
https://www.semiconductors.org/the-largest-share-of-u-s-industry-fab-capacity-is-in-the-united-states-not-china-lets-keep-it-that-way/

CHINA'S PATH TO IC SELF-SUFFICIENCY

Since coming to power in 2012, President Xi has gradually elevated the strategic importance of the IC industry as critical to China's economic development and national security. In this respect, raising self-sufficiency in semiconductors is seen by Chinese leadership as imperative.[132] With a web of policies subsidizing and prioritizing semiconductor technology, China's national goal is to achieve global leadership in every stage of the semiconductor manufacturing process by 2030. As such, policymakers have pushed a flurry of official and unofficial measures to upgrade China's IC industry.[133]

Official Measures

In 2014, the Chinese government published the Guidelines to Promote the National Integrated Circuit Industry (IC Guidelines), which launched a nationwide effort to develop a completely indigenous end-to-end semiconductor industry. The IC Guidelines established a National Integrated Circuit Investment Fund (National IC Fund) with an initial RMB 138.7 billion ($20 billion), with the explicit objective to increase China's domestic market share to a minimum of 70% by 2025. The fund also finances the acquisition of foreign semiconductor companies throughout the supply chain.

The following year, China released the MIC 2025 industrial policy plan, which underpinned President Xi's ambition to elevate China as a global technology powerhouse. Updated in early 2018, the plan highlighted China's continued determination to ascend the global ranks of technological innovation. Notably, the revised plan prioritizes the IC industry and identifies it as the first of 10 key industries slated for industrial upgrading. The Made in China Implementation Roadmap raises the already ambitious targets for China's IC market size and domestic production volume for 2020 and 2030, signifying more aggressive goals coupled with intensified policy supports (Table 3-2).

Table 3-2: China's IC Self-Sufficiency Goal in MIC 2025

	2015	2020	2030
Original Roadmap (2015)	Size of China's IC market reaches 36% of global market	Size of China's IC market reaches 43.5% of global market share	Size of China's IC market reaches 46% of global market share
	Domestic production reaches $48.3 billion (41% of domestic market demand)	Domestic production reaches $85.1 billion (49% of domestic market demand)	Domestic production reaches $183.7 billion (75% of domestic market demand)
Revised Roadmap (2017)	N/A	Size of China's IC market reaches 60% of global market share	Size of China's IC market reaches 70% of global market share
		Domestic production reaches $140 billion (58% of domestic market demand)	Domestic production reaches $305.1 billion (80% of domestic market demand)

Source: MIC 2025 Implementation Roadmap.

132 Paul Triolo et al., "Xi Jinping Puts 'Indigenous Innovation' and 'Core Technologies' at the Center of Development Priorities," *New America*, May 1, 2018. https://www.newamerica.org/cybersecurity-initiative/digichina/blog/xi-jinping-puts-indigenous-innovation-and-core-technologies-center-development-priorities/

133 For detailed discussion of China's policies, see Semiconductor Industry Association, "Written Comments to the United States Trade Representative Regarding the Initiation of a Section 301 Investigation into China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation," October 5, 2017. https://www.semiconductors.org/wp-content/uploads/2019/03/SIA-Submission-to-USTR-China-Section-301-Investigation-October-5-20171.pdf

These and other central policies channel government funding into the IC industry. The National IC Fund, which focuses on strengthening the domestic semiconductor supply chain, raised around $150 billion in 2014 and another $29 billion in 2019.[134] From September 2014 to August 2018, the fund invested in more than 70 companies and projects across multiple provinces and different parts of the IC supply chain, covering IC manufacturing, design, material, and equipment.[135] There are also multiple local funds available to support IC industry development, including the Shanghai IC Fund (RMB 10 billion) and Beijing IC Development Fund (RMB 30 billion).[136] Additionally, local governments provide preferential loans, preferential income tax rates and rebates, direct grants, and other incentives to support IC firms.[137] The OECD estimates that total PRC government support exceeds 30% of the annual revenues of leading Chinese chipmaker SMIC. According to the OECD, China's four state-backed semiconductor companies received a total of $4.85 billion in below-market loans from China's financial institutions between 2014 and 2018, accounting for 98% of below-market borrowing among the 21 companies identified in the report.[138]

Beyond pouring money into local IC firms with the goal of creating national champions, Chinese government policies also encourage domestic tech companies to attain IC technology through mergers and acquisitions (M&A). From 2000 through 2019, Chinese firms invested about $4 billion in the U.S. semiconductor industry.[139] Chinese IC firms now face more barriers to acquire critical technologies through M&A, due to tougher scrutiny from the U.S. and the rest of the world. In 2018, the U.S. expanded the CFIUS' mandate to review foreign investment with a minority interest instead of a controlling share. For example, in 2017, former President Trump blocked Canyon Bridge Capital Partners, a U.S.-headquartered private equity firm reportedly funded by the Chinese government, from acquiring Lattice Semiconductor Corporation, a U.S. chipmaker, for $1.3 billion.[140] The strong stance of the U.S. to limit China's ability to use M&A as a tool to acquire core intellectual property (IP) prompted other countries to follow suit, similarly tightening their investment screening mechanisms.[141]

134 John VerWey, "The Health and Competitiveness of the U.S. Semiconductor Manufacturing Equipment Industry," U.S. International Trade Commission, July 2019. https://www.usitc.gov/publications/332/working_papers/id_058_the_health_and_competitiveness_of_the_sme_industry_final_070219checked.pdf

135 Tianlei Huang, "Government-Guided Funds in China: Financing Vehicles for State Industrial Policy," Peterson Institute for International Economics, June 17, 2019. https://www.piie.com/blogs/china-economic-watch/government-guided-funds-china-financing-vehicles-state-industrial-policy

136 Adele Hars, "China: Investment Fever Kicks IC Industry into High Gear,“ Applied Materials, July 2015. http://www.appliedmaterials.com/nanochip/nanochip-fab-solutions/july-2015/china-investment-fever-kicks-ic-industry-into-high-gear

137 John VerWey, "The Health and Competitiveness of the U.S. Semiconductor Manufacturing Equipment Industry," U.S. International Trade Commission, July 2019. https://www.usitc.gov/publications/332/working_papers/id_058_the_health_and_competitiveness_of_the_sme_industry_final_070219checked.pdf

138 OECD, "Measuring Distortions in International Markets: The Semiconductor Value Chain," December 12, 2019. https://www.oecd-ilibrary.org/trade/measuring-distortions-in-international-markets_8fe4491d-en

139 Rhodium Group and National Committee on U.S.-China Relations, "The U.S.–China Investment Hub," accessed June 2020. https://www.us-china-investment.org/

140 Jalinous et al., "CFIUS: President Trump Blocks Acquisition of Lattice Semiconductor by Canyon Bridge," White & Case Law, September 18, 2017. https://www.whitecase.com/publications/alert/cfius-president-trump-blocks-acquisition-lattice-semiconductor-canyon-bridge

141 For example, see Mariko Kodaki, "Japan Eyes Screening Technology Investments as Small as 1%," Nikkei Asian Review, September 17, 2019. https://asia.nikkei.com/Economy/Japan-eyes-screening-technology-investments-as-small-as-1

Unofficial Measures

In addition to official measures supporting domestic companies, Beijing also employs policies that put foreign firms at a competitive disadvantage and makes market access contingent on conditions like technology transfer.[142] Discriminatory policies and practices include the following:

- **Joint venture and forced technology transfer**: Providing know-how and technology to a Chinese partner is a basic requirement in many industry segments. Foreign ICT firms are frequently required to transfer key technologies and development processes as a price of entry to the China market.

- **Domestic procurement**: Some government or state-owned enterprise procurement may exclude products that do not meet indigenous innovation criteria and favor imported products whose suppliers are willing to transfer technology. In 2019, an order from the CCP's Central Office ordered all government offices and public institutions to remove foreign computer equipment and software within three years.[143]

- **State-sponsored cyber-espionage**: China's security ministries engage in cyber-hacking to access U.S. ICT trade secrets and IP. In a notable example, Fujian Jinhua Integrated Circuit Co., a Chinese state-backed startup, was accused of stealing U.S. semiconductor IP; it was subsequently restricted from doing business with U.S. companies.[144]

- **Standards and product certification**: Developing and imposing national standards in strategic industries that often deliberately differ from international standards in order to impede market access for foreign technology and to favor Chinese technology.[145] In July 2020, China's National Information Security Standardization Technical Committee (TC260) issued draft supply chain standards for a wide range of IT products, which could significantly restrict U.S. suppliers.

In sum, Beijing has employed policies and nonmarket practices that help Chinese firms catch up, become self-sufficient, and subsidize technological development and expansion. These government-led approaches promote building out manufacturing capabilities and acquiring foreign technology. China's illicit practices in this industry—including a history of forced-technology transfer, lack of IP protection, and conditioning market access on technology sharing—underpin U.S. concerns about competitiveness and national security risks in the semiconductor industry.

ANALYSIS: WHAT ARE THE COSTS?

The above sections describe U.S. leadership in the global semiconductor industry, the associated economic and national security benefits, and the importance of access to China. As noted, U.S. policymakers have started to question the benefits of integration with China in tech-intensive and security-adjacent industries like semiconductors—especially upstream inputs such as manufacturing tools, amid concerns about overreliance, technology theft or replication, cyber-enabled crimes, and future competitiveness. The Trump administration implemented policies aimed at decoupling from China in semiconductors. These policies carry risks for the industry, including being cut out of its largest export and sales market that in turn fuels U.S. R&D investments. This outcome

142 For detailed discussion of China's policies, see Semiconductor Industry Association, "Written Comments to the United States Trade Representative Regarding the Initiation of a Section 301 Investigation into China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation," October 5, 2017. https://www.semiconductors.org/wp-content/uploads/2019/03/SIA-Submission-to-USTR-China-Section-301-Investigation-October-5-20171.pdf

143 Yuan Yang and Nian Liu, "Beijing Orders State Offices to Replace Foreign PCs and Software," Financial Times, December 8, 2019. https://www.ft.com/content/b55fc6ee-1787-11ea-8d73-6303645ac406

144 Kate O'Keeffe, "U.S. to Restrict Chinese Chip Maker from Doing Business with American Firms," The Wall Street Journal, October 29, 2018. https://www.wsj.com/articles/u-s-restricts-state-owned-chinese-chip-maker-from-doing-business-with-american-firms-1540837561

145 Jodi Xu Klein, "It's Not Just the US: Around the World, Doors Are Shutting on Chinese Investment," *SCMP*, September 14, 2018. https://www.scmp.com/business/banking-finance/article/2163974/its-not-just-us-around-world-doors-are-shutting-chinese

could have consequences for U.S. technological leadership in the sector and associated global market share. In this section, we review policies that threaten the main channels of U.S-China engagement in the semiconductor industry and estimate the potential cost of those policies to the U.S. semiconductor industry.

EXPORT CONTROL: POLICIES AND IMPLICATIONS

Over the past two years, the U.S. has adopted and proposed several measures that restrict the export of certain semiconductor technology, to address China's military-civil fusion policies and the violation of U.S. export control laws by Chinese entities. These include the following:

- The U.S. Department of Commerce (DOC) has added several leading Chinese firms that are major purchasers of U.S. semiconductors to the Entity List, requiring a license to export, re-export, and retransfer U.S.-origin products and technology to those entities—typically with a presumption of denial for a license application. Recent additions to the list include chip buyers such as Huawei and Hikvision as well as firms that specialize in artificial intelligence and visual recognition, like Sensetime and Megvii. License requirements for blacklisted firms apply beyond U.S. borders to the transfer of technology that incorporate a certain amount (typically 25%) of controlled U.S. content.

- Given that companies like Huawei were able to continue to purchase foreign-made chips from non-U.S. suppliers as well as from U.S. tech firms with overseas production facilities, despite being on the Entity List, the DOC imposed further restrictions in May by amending its foreign direct product rule. The rule requires an export license for semiconductors that are produced or developed by Huawei if those chips have been designed using certain U.S.-origin technology and equipment.[146]

- In April 2020, the DOC amended the Export Administration Regulation to change the definition of the terms *military end use* and *military end user*, a change that took effect in June. The scope was expanded from entities with direct involvement in the production of military items to include entities that support or contribute to those items.[147] Semiconductor sales to a much wider range of companies with small or tangential commercial ties with the military will likely be subject to this rule, requiring a license for export to China.

There are more export control measures in the pipeline. The Export Control Reform Act passed in 2018 requires the DOC to identify and control "emerging" and "foundational" technologies that may be essential to U.S. national security. These technologies could then be subject to tighter export controls, potentially being regulated similarly to nuclear secrets and fighter jets. Lists of foundational technologies have not yet been proposed but are broadly understood to include semiconductors.

BEIJING'S EXPORT CONTROL POLICIES

Despite strong condemnation of U.S. actions from Chinese officials, Beijing so far has taken a largely rhetorical and measured response. Beijing's current strategy may reflect efforts to hold retaliatory measures in reserve should decoupling accelerate.

In July 2020, China published draft export control legislation that requires licenses for exports of sensitive technologies and allows China's Ministry of Commerce (MOFCOM) to blacklist foreign firms. MOFCOM's authority would extend overseas, requiring foreign firms to apply for a license before selling or transferring products with

146 Akin Gump, "Commerce Department Extends Export Controls over Foreign-Made Items in Huawei's Contract Manufacturing Supply Chain," May 19, 2020. https://www.akingump.com/en/news-insights/commerce-department-extends-export-controls-over-foreign-made-items-in-huaweis-contract-manufacturing-supply-chain.html

147 U.S. Department of Commerce, Bureau of Industry and Security, "Federal Register Vol.85, No.82," April 28, 2020. https://www.bis.doc.gov/index.php/documents/regulations-docs/federal-register-notices/federal-register-2020/2545-85-fr-23459/file

Chinese content above a certain threshold.[148] The wording of the new draft law is ambiguous and grants authorities significant investigative and regulatory power, such as entering business premises, conducting interviews, accessing business-related documents, and seizing business assets.

In 2019, MOFCOM also stated that it was developing its own "unreliable entities list." While the formal rules governing this list were issued in September 2020, the list itself has yet to be published.[149] Other nontariff trade barriers that China has leaned on in the past could similarly lead to further semiconductor decoupling, including cybersecurity-related measures, custom clearance procedures, licensing, and anti-trust investigations.

IMPLICATIONS: U.S. SEMICONDUCTOR INDUSTRY'S GLOBAL LEADERSHIP UNDER THREAT

The U.S. is addressing the national security risks related to China's military-civil fusion strategy as well as Beijing's ambition to lead the world in advanced technologies. Maintaining overall U.S. dominance in semiconductor technology is an important component of the U.S. response, but overly broad restrictions may create unintended consequences that diminish U.S. overall competitiveness and security in the long run. Direct implications for U.S. firms include the potential delay or cancellation of shipments as they navigate stricter licensing regulations and invest in supply chain tracing capabilities. Export controls and possible retaliation from China could have a more far-reaching impact on U.S. global leadership in the industry if such measures lead to a loss in global market share for U.S. semiconductors, which currently stands at nearly 50%.[150]

Already, Chinese firms and public institutions are pushing to source chips and equipment from non-U.S. firms, and Chinese equipment manufacturers are proactively substituting U.S. supply for fear of losing access to U.S. technologies.[151] Hikvision, a Chinese manufacturer and supplier of video surveillance equipment that was added to the Entity List, has stated it is actively switching to non-U.S. suppliers.[152] More prominent is Huawei, which has already switched away from U.S. chips not only for its smartphones[153] but for its advanced 5G base stations as well.[154] If non-U.S. alternatives are available, Chinese and international companies are more likely to change suppliers to reduce the compliance burden of U.S. export controls. Companies not directly impacted by export controls may also view U.S. suppliers as unreliable, creating a multiplier effect that could be substantial.

148 Ting Ting Liu, Lester Ross, and Kenneth Zhou, "China Publishes Draft Export Control Law," *JD Supra*, January 16, 2020.
https://www.jdsupra.com/legalnews/china-publishes-draft-export-control-law-58113/

149 Reuters, "China Publication of 'Unreliable Entities List' Depends on Sino-U.S. Trade Talks: Sources," October 11, 2019.
https://www.reuters.com/article/us-usa-trade-china-entities/china-publication-of-unreliable-entities-list-depends-on-sino-u-s-trade-talks-sources-idUSKBN1WQ28L

150 Alex Capri, "US-China Tech War and Semiconductors," Hinrich Foundation, January 2020.
https://hinrichfoundation.com/trade-research/global-trade-research/thought-leadership/semiconductors-at-the-heart-of-the-us-china-tech-war/

151 Yuan Yang, "US Tech Backlash Forces China to Be More Self-Sufficient," *Financial Times*, January 14, 2020.
https://www.ft.com/content/c6993200-1ff3-11ea-b8a1-584213ee7b2b;
Antonio Varas and Raj Varadarajan, "How Restricting Trade with China Could End US Semiconductor Leadership," Boston Consulting Group, March 9, 2020.
https://www.bcg.com/publications/2020/restricting-trade-with-china-could-end-united-states-semiconductor-leadership.aspx

152 Sarah Dai, "Chinese Surveillance Giant Hikvision Stockpiles Crucial Parts to Guard against Potential US Ban," SCMP, July 22, 2019.
https://www.scmp.com/tech/enterprises/article/3019564/chinese-surveillance-giant-hikvision-stockpiles-crucial-parts

153 Fumie Yaku, "Huawei Teardown Shows US Ban Made Company Turn to Chinese Parts," Nikkei Asian Review, May 14, 2020.
https://asia.nikkei.com/Spotlight/Huawei-crackdown/Huawei-teardown-shows-US-ban-made-company-turn-to-Chinese-parts

154 Dan Strumpf, "Huawei's 5G Dominance Threatened by U.S. Policy on Chips," *The Wall Street Journal*, June 21, 2020.
https://www.wsj.com/articles/huawei-struggles-to-escape-u-s-grasp-on-chips-11592740800

Substituting U.S. chips will take time and will not happen in the next 12 to 18 months, but it is plausible over a multiyear time horizon.[155] According to the Semiconductor Industry Association (SIA):

> *Broad unilateral restrictions on Chinese access to U.S. technology could significantly deepen and accelerate the share erosion for U.S. companies. Established alternative non-U.S. suppliers exist already for over 70% of Chinese semiconductor demand. Over the next three to five years, U.S. companies could lose 8 percentage points of global share and 16% of their revenues, if the U.S. maintains the restrictions enacted with the current Entity List. As a result, South Korea would likely overtake the U.S. as world semiconductor leader in a few years; China could attain leadership in the long term.*[156]

Reduced market share and revenue will translate into less R&D spending for U.S. semiconductor firms. R&D investment is essential for firms' competitiveness in this industry as fast-paced technological development requires constant upgrading of designs and process technology. Industry-wide investment rates of R&D have been roughly 30% of sales for the past decade.[157] A significant drop in sales due to export controls and other policies that contribute to decoupling will impact U.S. semiconductor companies' ability to design and produce advanced chip components, creating a downward spiral of decreasing R&D, sales, and market share, thus leading to the eventual demise of U.S. global leadership in this industry. As a result, the economic costs of any policies should be carefully considered.

Estimating Costs from Lost China Sales

In this section, we attempt to quantify the impact of reduced sales to China due to export controls and the resulting characterization of U.S. companies as unreliable suppliers. The impact of tariffs is deliberately left out in this calculation given its modest impact compared with export controls, with total calculated duties paid for 2019 of $438 million,[158] which equals roughly 20% of total U.S.-based semiconductor sales in 2019 (about $200 billion).[159]

The estimates below do not capture the full costs of decoupling, as we do not consider the impact on channels such as investment; nor do they consider the impact of intermediaries in third countries replacing U.S. supply in response to export controls. Further, our estimates do not include secondary effects such as how reduced spending by semiconductor industry employees would affect demand in other sectors. Given these limitations, this section provides only a broad picture of the direct costs of decoupling in the semiconductor space.

Modeling the impact of U.S.-China decoupling in semiconductors is complicated and relies on assumptions about how global firms interact across different market segments, as well as granular data about firm-level transactions. We refer to a March 2020 report published by Boston Consulting Group (BCG), which draws on proprietary firm-level data as a starting point for understanding how U.S.-China decoupling would impact sales revenue and spending by semiconductor firms. BCG models a full decoupling scenario in which U.S. semiconductor sales to Chinese customers, as well as sales to customers in third countries that become decoupled from the U.S., drop to zero.[160] This outcome

155 Dan Wang, "The Weakening Bite of US Tech Sanctions," Gavekal, November 13, 2019. https://research.gavekal.com/article/weakening-bite-us-tech-sanctions

156 Antonio Varas and Raj Varadarajan, "How Restricting Trade with China Could End US Semiconductor Leadership," Boston Consulting Group, March 9, 2020. https://www.bcg.com/publications/2020/restricting-trade-with-china-could-end-united-states-semiconductor-leadership.aspx

157 Semiconductor Industry Association, "2020 Factbook," April 21, 2020. https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

158 This number is based on SIA's monthly tracker of U.S. semiconductor imports from China and duties paid under Section 301 on them.

159 Semiconductor Industry Association, "2020 Factbook," April 21, 2020. https://www.semiconductors.org/wp-content/uploads/2020/04/2020-SIA-Factbook-FINAL_reduced-size.pdf

160 BCG predicts that U.S. firms' China-related sales revenue in a full decoupling scenario would drop to zero almost immediately and that China, South Korea, Japan, and other countries will fully fill the gap in demand.

would reduce annual sales revenue by $83 billion and global share by 18%, and result in 124,000 lost jobs. BCG assumes that U.S. semiconductor firms reduce expenditures at least in proportion to the fall in revenue. Thus, such a drop in revenue would lead to a reduction in R&D spending by at least $12 billion and capital spending by $13 billion.[161]

BCG's more modest, base-case decoupling scenario that results in China substituting 50% of its replaceable U.S. chip supply over two to three years would result in an annual $36 billion loss to U.S. semiconductor revenue, equivalent to an 8% reduction in U.S. global market share.[162] A 50% drop in revenue would cause a loss of 40,000 U.S. jobs, between $5 billion and $10 billion in reduced R&D spending, and an $8 billion drop in capital spending.[163]

We build on BCG's decoupling scenarios by estimating how a decrease in sales revenue would affect U.S. production and employee pay. For this exercise, we assume that a drop in U.S. semiconductor sales revenue ($83 billion in the event of full decoupling and $36 billion in the base case) from China is equivalent to the drop in final demand, or the demand for goods that are not used for the manufacture of semiconductors and related devices.[164] The BEA's 2012 total requirements table lays out how much production is required, directly and indirectly, to deliver $1 of a commodity for final use. An $83 billion drop in demand for semiconductors would implicate $124 billion in production. A $36 billion drop in demand would implicate about $54 billion in total annual production, $18 billion of which would come from nonsemiconductor industries that are involved in the manufacture of semiconductors.[165] The nonsemiconductor industries that would be hardest hit are management services, metals, and appliances.

By cross-referencing this drop in production to U.S. input-output tables, we approximate the impact on employee compensation, a comprehensive measure that includes wages, salaries, and noncash benefits like employer contributions to pension plans, to health insurance, and to social insurance programs.[166] A $124 billion drop in gross output of semiconductors, related devices, and the industries involved in their production would implicate about $46 billion in employee compensation.[167] The base-case decoupling scenario would implicate $20.1 billion in compensation. We summarize these results in Table 3-3.

161 Antonio Varas and Raj Varadarajan, "How Restricting Trade with China Could End US Semiconductor Leadership," Boston Consulting Group, March 9, 2020. https://www.bcg.com/publications/2020/restricting-trade-with-china-could-end-united-states-semiconductor-leadership.aspx

162 BCG assumes that U.S. suppliers will be 50% to 100% substituted if there is one or more established, alternative non-U.S. supplier with a market share of 10% or more; 30% to 40% if there is no established alternative but the combined share of smaller alternative suppliers is 10% or more; and no substitution if neither of those two conditions are met. Their estimates are based on 2018 figures. See methodology appendix for more detail.

163 BCG came to the lower bound of this range by assuming that R&D spending will decrease in exact proportion to revenue. The upper bound is based on their Proprietary Shareholder Analytics, which predicts that companies will cut this spending by much more to maintain shareholders' rate of return.

164 Exports are treated as final demand in input-output tables. In this exercise we assume that sales are equivalent to exports. As discussed, however, sales capture intrafirm sales, transportation costs, and intangible value that may not be included in export data.

165 We use 2018 as a base year to accord with BCG estimates. U.S. Department of Commerce, Bureau of Economic Analysis, "Input-Output Accounts Data, 2012," accessed March 2020. https://www.bea.gov/industry/input-output-accounts-data

166 U.S. Department of Commerce, Bureau of Economic Analysis, "Chapter 10: Compensation of Employees," November 2019. https://www.bea.gov/system/files/2019-12/Chapter-10.pdf

167 U.S. Department of Commerce, Bureau of Economic Analysis, "Input-Output Accounts Data," 2012. https://www.bea.gov/industry/input-output-accounts-data

Table 3-3: Impact of Lost Sales on U.S. Semiconductor Industry, Employment, and Production under U.S.-China Decoupling

USD billion, percent of global market share, and thousands of jobs

Indicator	Industry Revenue	Global Market Share (%)	Industry Capital Spending	Industry R&D Spending	U.S. Jobs	Total U.S. Employee Compensation	Total U.S. Production
Full Decoupling	-83	-18	-13	-12 to -24	-124,000	-46	-124
Modest Decoupling	-36	-8	-8	-5 to -12	-40,000	-20	-54

Sources: Boston Consulting Group, U.S. Bureau of Economic Analysis, RHG calculations.

Both decoupling scenarios above imply severe risks to the U.S. semiconductor industry's leadership position in the world. The lost market share, coupled with the concurrent rise in global sales and revenue of other countries, would diminish U.S. innovation leadership as lost sales translate to lost R&D investment, as noted extensively in previous sections.

Future Costs

The above estimates represent costs from reduced sales over a three- to five-year time frame. Yet the industry economics and policy disruptions at play suggest that, over a longer period, tensions and costs will multiply.

Proposed decoupling measures in both the U.S. and China would significantly reduce U.S. firms' revenues beyond a three-year time frame, though the speed and extent to which substitution will occur is uncertain. The midpoint between BCG's full U.S.-China decoupling scenario and the modest base case would equate to a 13% loss of global market share. This would impose large opportunity costs on the U.S. semiconductor industry and economy. As of early 2020, the global semiconductor market was predicted to grow from $470 billion in 2018 to $730 billion in 2027.[168] A 13% drop in market share would equate to $95 billion in forgone revenue in 2027. Applying historical revenue to spending ratios, the U.S. semiconductor industry would be spending about $19 billion less per year on R&D than it otherwise would in 2027, with billions less spent on capital equipment and employees as well. Annual reductions in innovative investment will in turn reduce U.S. competitiveness and market share, forcing them into less profitable segments of the market.[169]

U.S. export controls drive our assessment of the decoupling impact on the U.S. semiconductor industry. Many assumptions are required to produce this calculation, and the results provide a reasonable picture of the direction and magnitude of impacts rather than a precise calculation. But the basic story of lower sales revenues, exports, and imports—accompanied by a drop in capital expenditures and outlays on innovation—is clear. About 75% of U.S. chips sold to China have established competitors. With a smaller total available global market, industrial production from semiconductor firms and related industries will fall. Some reshoring in other parts of the ICT sector could partially offset this drop—but not enough to make up the shortfall.

168 Fortune Business Insights, "Semiconductor Market to Reach USD 730.29 Billion by 2026; Growing Adoption of Electronics to Augment Growth, States Fortune Business Insights," March 2, 2020. https://www.globenewswire.com/news-release/2020/03/02/1993314/0/en/Semiconductor-Market-to-Reach-USD-730-29-billion-by-2026-Growing-Adoption-of-Electronics-to-Augment-Growth-states-Fortune-Business-Insights.html

169 Alex Capri, "US-China Tech War and Semiconductors," Hinrich Foundation, January 2020. https://hinrichfoundation.com/trade-research/global-trade-research/thought-leadership/semiconductors-at-the-heart-of-the-us-china-tech-war/

INTERPRETATION: WHAT DOES IT MEAN FOR THE U.S. ECONOMY?

These quantitative estimates do not capture the full stakes for U.S. semiconductors. The dynamism and innovation in this industry over the past half century was a marvel that was not foreseen by many. The pattern of future evolution under newly regulated conditions is at least as difficult to anticipate. Yet several realities are foreseeable.

First, China-related revenue is a material share of total U.S. semiconductor industry income, and forgoing that market means lower economies of scale for U.S. chipmakers. Much of that scale will be picked up by foreign competitor firms, including many domestic Chinese companies. All things equal, that will mean reduced U.S. income and competitiveness outside of China as well. In the near term, there are no alternative markets to absorb lost Chinese demand, and the subsidy policy discussion underway in the U.S. is designed to onshore semiconductor supply chains, which will not offset the loss of demand.[170] While in the longer term it is unlikely that the U.S. would—or could—subsidize enough to make up for the loss of China's market, targeted manufacturing and research incentives may go a long way in ensuring U.S. supply chain resilience and long-term technological leadership. Moreover, developing new IP is a function of R&D spending, which in the U.S. depends on global revenue, so decoupling threatens the future pace of U.S. innovation as well. Neither U.S. nor Chinese commercial interests would be strengthened by decoupling, but given its leading position in the semiconductor industry, the U.S. has more to lose. As with other sectors, this does not mean that business as usual should simply be accepted, but that the economic costs of any policies should be considered when formulating related policies.

Second, retrenchment of U.S. chipmakers from the China market would reduce their influence in global emerging technologies and have consequences for U.S. national security. The global semiconductor ecosystem is largely centered in the U.S., thanks to its ability to attract the greatest talent from around the world in basic science, industrial engineering, management, productization, application development, and venture finance. The effectiveness of this mixture of talent and capital allowed the U.S. to establish a sustainable advantage in semiconductors for decades, with tangible benefits for U.S. security interests. Semiconductors and the architecture they are built on are the key to competitiveness in emerging technologies, including dual-use and military technologies such as supercomputing, artificial intelligence, and quantum computing. Certainly, there are supply chain imbalances, such as an overall decline in actual chip-making capacity in the U.S. coupled with a preponderance of contract chip production located in Asia, which U.S. policymakers should consider federal investments to address. But policy uncertainty—be it the constant risk of additional tariffs, broader export controls, U.S. content rules, or other technology restrictions—makes U.S. firms less reliable partners and suppliers in global markets that take decades of research, design, high-skill training, and capital expenditure to secure. This not only reduces Chinese OEMs' willingness to acquire U.S. chips but also creates risks for firms in allied countries that may be forced to sacrifice access to the world's largest and fastest-growing semiconductor market in order to continue working with U.S. chipmakers. Hasty decoupling that forces foreign firms to "de-Americanize" their semiconductor activities because they are unwilling to disengage with China threatens U.S. chipmakers' foundational position in global technology value chains and the attendant strategic benefits to U.S. security interests.

Targeted export controls and other tools can effectively address narrow and legitimate national security concerns related to China. The 2015 and 2018 entity listings targeting China's high-performance computing infrastructure that was directly engaged in "nuclear weapons simulation"[171] is one such example. In addition, the reported U.S. pressure on the Dutch government not to grant a license for the export of an advanced machine tool used for

170 See Rep. Michael McCaul's CHIPS for America Act, H.R.7178, 116th Congress (2019-2020). https://www.congress.gov/bill/116th-congress/house-bill/7178?s=1&r=5

171 U.S. Department of Commerce, Bureau of Industry and Security, "Addition of Certain Persons to the Entity List; and Removal of Person From the Entity List Based on a Removal Request," Feburary 18, 2020. https://www.federalregister.gov/documents/2015/02/18/2015-03321/addition-of-certain-persons-to-the-entity-list-and-removal-of-person-from-the-entity-list-based-on-a

chip manufacturing to China[172] is the kind of narrow action that can significantly impact China's ability to fabricate advanced chips, ensuring China remains reliant on more controllable foreign foundries without cutting off access to all technology.[173] The 2018 addition to the Entity List of a Chinese chipmaker that was indicted for the theft of U.S. IP was essential to protect the U.S. industrial base.[174] These types of narrowly tailored actions should continue to be pursued by the U.S. government to address legitimate and effective national security objectives.

Finally, decoupling has spurred China to double down on its ongoing self-sufficiency efforts to form a parallel value chain in semiconductors, further threatening the U.S. global strategic advantage in the field. China is not on par with U.S. industry sophistication, and its ability to attain self-sufficiency in semiconductors is not a foregone conclusion, but it has made strides in mastering some capabilities that were cutting edge just a few years ago, and Beijing is intensely motivated to build indigenous capabilities. For years China has invested more money toward technology deepening in semiconductors than the marketplace could even absorb. Forced separation from U.S. innovation would likely slow China's innovation progress, but it would also likely lead to separate global chip technology spheres, one based on U.S. technology and another based on China's products. Such a bifurcated global technology landscape is less desirable than the U.S.-dominated market structure now in place. Having Chinese rather than U.S. and allied IP at the foundation of new technology value chains and global technology standards could create comparative advantages for China that last for decades. Given the importance of semiconductors to U.S. national security, the U.S. should consider the merits of targeted federal investments to create a stronger semiconductor supply chain on U.S. soil—including semiconductor manufacturing, an area in which it currently lags in leadership compared with chip sales and R&D. Yet it should also accept that, due to no obvious substitute for the large and growing Chinese market, it is critical that U.S. chip firms retain access to the Chinese market and are able to reinvest revenues from their China sales back into U.S.-based chip production and R&D to maintain their global leadership position, enabling the U.S. to set the standards for the future. This outcome is preferable to a bifurcated global semiconductor ecosystem that diminishes overall U.S. leadership and influence over the global development of new technologies.

172 Alexandra Alper, Toby Sterling, and Stephen Nellis, " Trump Administration Pressed Dutch Hard to Cancel China Chip-Equipment Sale: Sources," *Reuters*, January 6, 2020. https://www.reuters.com/article/us-asml-holding-usa-china-insight/trump-administration-pressed-dutch-hard-to-cancel-china-chip-equipment-sale-sources-idUSKBN1Z50HN

173 Brookings TechStream, "The Chip-Making Machine at the Center of Chinese Dual-Use Concerns," June 30, 2020. https://cset.georgetown.edu/article/the-chip-making-machine-at-the-center-of-chinese-dual-use-concerns/

174 U.S. Department of Commerce, Bureau of Industry and Security, "Addition of Fujian Jinhua Integrated Circuit Company, Ltd (Jinhua) to the Entity List," October 29, 2018. https://www.commerce.gov/news/press-releases/2018/10/addition-fujian-jinhua-integrated-circuit-company-ltd-jinhua-entity-list

Chemicals Industry

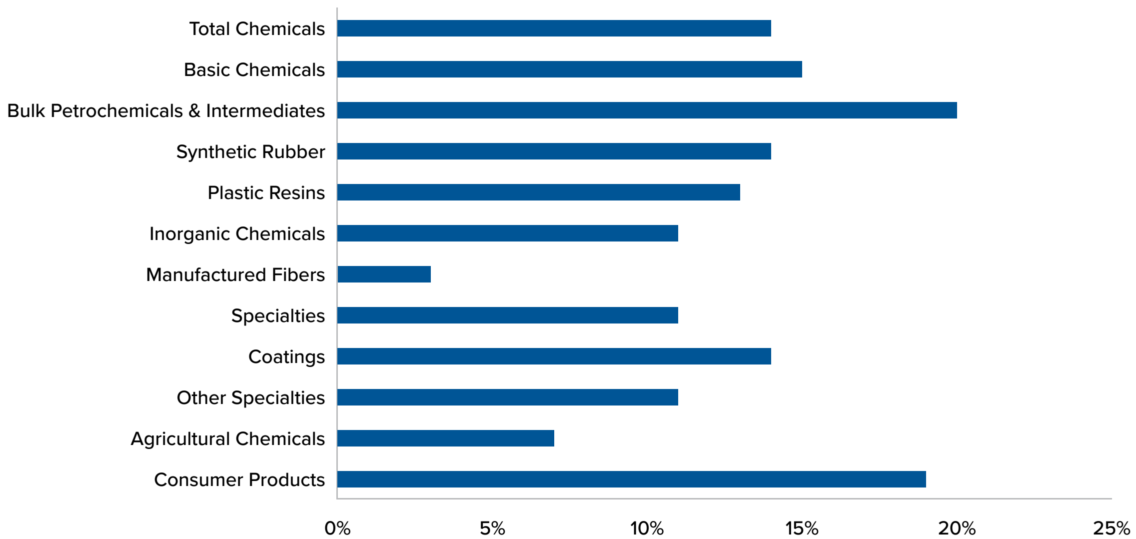
INDUSTRY SNAPSHOT

The chemicals industry is vast, supporting more than 7% of global GDP in 2017.[175] Chemicals are used as inputs in nearly every step of the manufacturing process. According to the American Chemical Council (ACC), more than 96% of all manufactured goods are directly touched by the "business of chemistry." Industry output can be classified into four main market-based segments: basic chemicals, which are typically incorporated into manufactured products or used in processing; specialty chemicals, which are differentiated and manufactured for specific technical uses; agricultural chemicals, which are used primarily by farmers; and consumer products, which are distinguished by packaging and advertising.[176]

The economics of chemicals vary by market segment, but in general chemicals manufacturing is capital- and energy-intensive and dependent on global supply chains—both within the chemicals industry and within chemicals-consuming industries—for raw materials, processing, and packaging to minimize costs. Additionally, chemicals manufacturing spans the value chain: basic chemicals have less product variation—meaning they are less differentiated and more substitutable—while specialty chemicals are more technologically advanced and used for processing into higher-value-added products.

The U.S. chemicals industry is a major global market participant. The U.S. is the second largest producer after China, providing 14% of the world's chemicals in 2019.[177] As shown in Figure 4-1, U.S. chemicals manufacturers are major producers in many segments. U.S. manufacturers produce 20% of the world's supply of bulk petrochemicals and intermediates (which includes 15% of the global supply of plastic resins), 20% of all consumer products chemicals, 16% of all synthetic rubber, and 14% of all inorganic chemicals.

Figure 4-1: U.S. Share of Global Chemicals Output by Segment, 2018*
Percentage of USD total



Source: Data from ACC, "2019 Guide to the Business of Chemistry." *The term *shipments* is equivalent to the term *turnover*, or value of output.

175 Oxford Economics, prepared for International Council of Chemical Associations (ICCA), "The Global Chemical Industry: Catalyzing Growth and Addressing Our World's Sustainability Challenges," March 2019, p. 10.
https://icca-chem.org/wp-content/uploads/2020/10/Catalyzing-Growth-and-Addressing-Our-Worlds-Sustainability-Challenges-Report.pdf

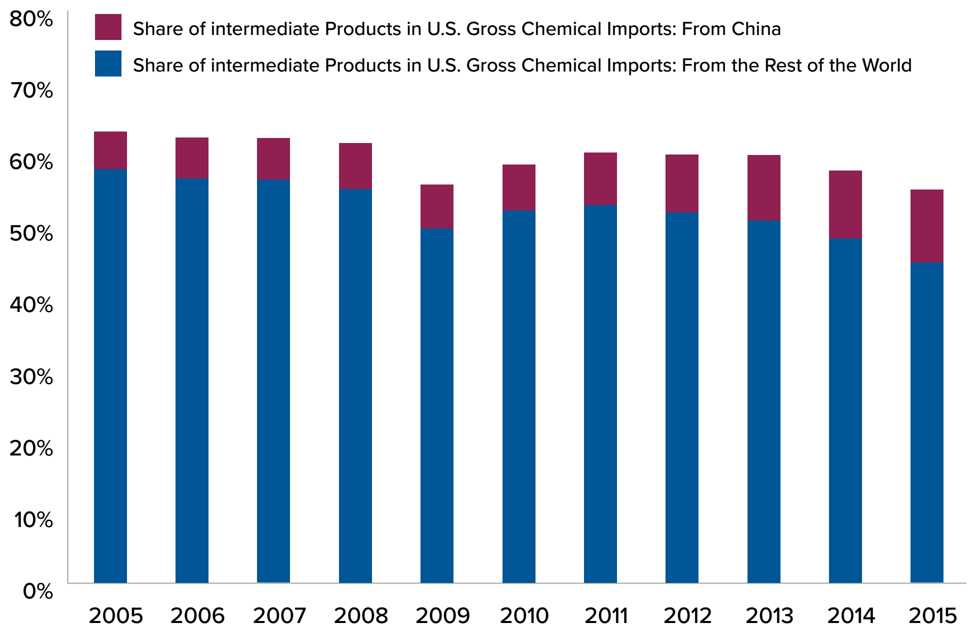
176 American Chemistry Council, "2020 Guide to the Business of Chemistry," June 2020.
https://www.americanchemistry.com/2020-Guide-to-the-Business-of-Chemistry.pdf

177 Ibid.

U.S. chemicals output depends on international linkages. The OECD's Global Value Chain (GVC) database shows foreign inputs accounted for 3.3% of U.S. gross chemicals and nonmetallic minerals exports in 2009 (latest year for which data are available), and U.S. chemicals exports were used as intermediate inputs in 4% of third countries' exports.[178] Compared with other countries, the U.S. is an active participant in chemicals GVCs, on par with the OECD average and more active than China.[179] To remain a leader in chemicals exports, the U.S. must retain access to global markets to supply inputs to chemical processing and other manufacturing, particularly in the electronics and cloud computing sectors. As Chinese and non-Chinese manufacturing expands in China, it is therefore imperative for the global competitiveness of U.S. chemical producers to have access to China's market. Chemicals are inputs not just to creating other chemicals; they are inputs to all manufactured goods. As Figure 4-2 shows, the majority of U.S. chemicals imports are intermediate products, which feed into domestic processing and production for U.S. exports or domestic consumption. China provides 10% of those imported intermediates. Reduced access to intermediate chemicals imports would weigh on U.S. chemicals production and exports as well as on downstream manufacturers that rely on U.S. chemical products and innovation.

Figure 4-2: Share of Intermediate Products in U.S. Chemical Gross Imports, 2005-2015

Percentage of USD total



Source: OECD Trade in Value-Added database.

178 The figures presented refer to OECD indexes of "backward participation" and "forward participation" in GVCs by country and industry. The backward participation index measures the value of imported inputs in the overall exports of a country, which indicates the contribution of foreign industries to the exports of a country by looking at the foreign value added embodied in gross exports. The forward participation index measures the share of a country's exported goods and services used as imported inputs to produce other countries' exports, which indicates the contribution of domestically produced intermediates to exports in third countries. OECD, "Global Value Chains Indicators," May 2013.
https://stats.oecd.org/Index.aspx?DataSetCode=GVC_INDICATORS

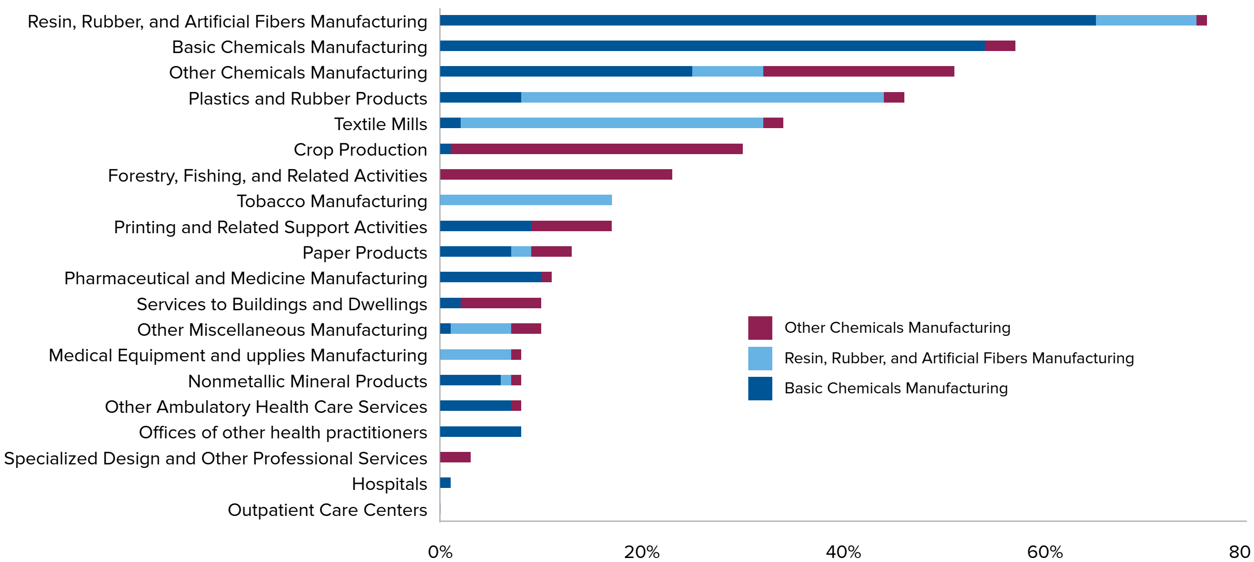
179 Domestically produced inputs can incorporate some of the foreign inputs. As such, there is overlap and potentially some double counting in GVC trade flows, as they are not value-added trade. Koen De Backeri and Sébastien Miroudot, "Mapping Global Value Chains," OECD, December 19, 2013.
https://www.oecd-ilibrary.org/docserver/5k3v1trgnbr4-en.pdf?expires=1587507255&id=id&accname=guest&checksum=EA26238DAF023B7A611F7C098FDB4875

Far-reaching supply chains allow the chemicals industry to reach economies of scale and contribute strongly to the U.S. economy. Value added by chemicals was $222.3 billion in 2019, more than 1% of total U.S. GDP.[180] The U.S. chemicals industry is also a massive employer, directly supporting 544,000 jobs in 2019, according to the BEA, 40% of which are high-skilled positions—engineers, scientists, chemists, technicians, and management. But chemicals-*related* employment is far greater. The ACC estimated that indirect employment of people working in other industries that support the industry was 1.94 million in 2019, while expenditure-induced activity (e.g., jobs supported by suppliers to chemicals supply chains, jobs in industries supported by employee wages) added another 1.97 million, bringing total U.S. chemicals industry-related employment to nearly 4.5 million in 2019.[181] Further, and as discussed in more detail below, highly innovative U.S.-based specialty chemicals reflect investments in R&D by U.S. firms and the U.S. taxpayer. Access to global markets will protect U.S. innovation and strengthen the position of the U.S. as the locus for chemicals IP and royalties.

The importance of chemicals to the U.S. economy is complex given they permeate so many other economic arenas. Chemicals are among the biggest intermediate inputs to U.S. industries—not just as raw materials but for producing intermediate and final goods. As Figure 4-3 shows, chemicals, rubber, and plastic manufacturing are most reliant on chemicals, but so are industries like textiles manufacturing, agriculture, pharmaceuticals, and several health care services.

Figure 4-3: Top 20 Industries Reliant on Chemicals as Intermediate Inputs by Segment

Percentage of industry intermediate output contributed by chemicals industries



Source: U.S. BEA input-output table, 2012.

The U.S. chemicals industry benefits substantially from free trade. The U.S. exported $136 billion in chemicals (excluding pharmaceuticals) in 2019, around 10% of total U.S. exports, making it one of the top U.S. exporting industries. More than half (68%) of U.S. chemicals exports are basic chemicals, a category that includes petrochemicals and plastic resins. The U.S. exported $92 billion in basic chemicals in 2019. The U.S. has long maintained a net exporter position in chemicals. The trade surplus is bolstered by strength in petrochemicals and plastic resins. The U.S. chemicals trade surplus was $35 billion in 2019. The U.S. imports chemicals too, but imports should be compared with domestic supply to better understand relative reliance. The BEA 2012 input-output table shows total imports account for less than 10% of total domestic supply in most chemical products.

180 American Chemistry Council, "2020 Guide to the Business of Chemistry," June 2020, p. 7. https://www.americanchemistry.com/2020-Guide-to-the-Business-of-Chemistry.pdf

181 Ibid.

The chemicals industry is capital intensive. Chemicals undergo processing and transformation, and the chemicals business must achieve economies of scale to remain viable. For these reasons, large plants, equipment, complex processes, automation, and technology requirements all contribute to capital costs.[182] U.S. chemicals industry capital investment on plants and equipment rose to about $35 billion in 2019, equivalent to 6% of total shipments (akin to total output value).[183] Capital spending takes a long time to plan and build out, making short-run investment adjustments difficult and costly.[184] One determinant of capital spending level is profit margins, which are lower in basic chemicals, given the importance of raw materials and oil prices, and higher in consumer products. The shale gas revolution in the U.S. has made it a very attractive destination for new investment, in part because the resulting price reductions for resources push down industry costs and buoy profit margins that fund capital expenditures.

The shale gas revolution has increased U.S. capacity to produce oil and gas domestically, causing energy prices to fall and significantly reducing raw materials costs for the U.S. petrochemicals industry. This is a tremendous opportunity for ethane, a primary raw material used as a feedstock in production of ethylene, which in turn is used in production of thousands of other chemicals. The shale revolution resulted in a 74% fall in the price of ethane from 2008 to 2018.[185] Low-cost ethane has led to highly efficient and cost-competitive chemicals production in the U.S., which boosted the share of domestic value-added in U.S. gross chemicals exports. Data from the OECD Trade in Value-Added database shows that domestic value-added in gross U.S. chemicals exports has consistently risen since 2011 (Figure 4-4), indicating improved U.S. competitiveness. In other words, increased production efficiency means more chemical products are now being manufactured in the U.S.

Figure 4-4: Share of Domestic Value Added in Gross U.S. Chemicals Exports, 2005-2015

Percentage of USD total

Source: OECD Trade in Value-Added database.

182 American Chemistry Council, "2019 Guide to the Business of Chemistry," June 2019, p. 45. https://store.americanchemistry.com/products/guide-to-the-business-of-chemistry-2019-electronic-version-copy

183 American Chemistry Council, "2020 Guide to the Business of Chemistry," p. 7. https://www.americanchemistry.com/2020-Guide-to-the-Business-of-Chemistry.pdf

184 Ibid.

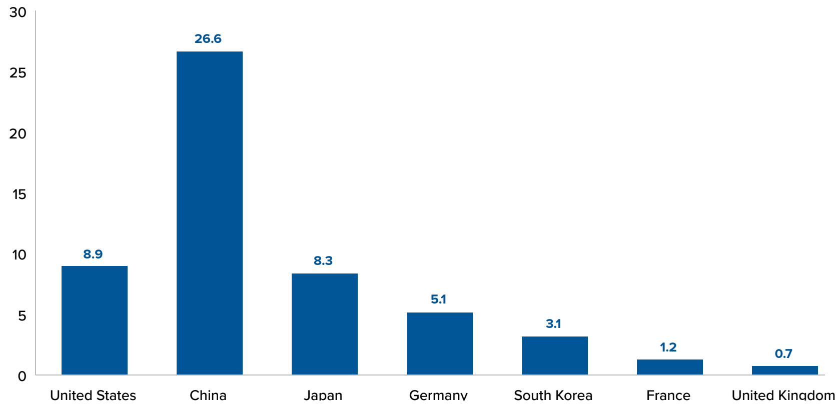
185 Calculated based on U.S. Energy Information Administration data. https://www.eia.gov/energyexplained/hydrocarbon-gas-liquids/prices-for-hydrocarbon-gas-liquids.php

Although the shale gas revolution makes the U.S. an increasingly attractive location for capital expenditures, substantial investments in the past decade have been made under the expectation that global demand would absorb the rising U.S. output enabled by low-cost raw materials. These conditions supported an average 18.5% profit margin across the U.S. chemicals industry in 2018.[186] But after ramping up supply, the cost advantages of operating in the U.S. disappear if firms lose access to the export markets that make those investments profitable. If U.S. manufacturers are cut off from global demand—particularly China's massive market—companies and investors alike face a hit to profit that in turn reduces incentives for future capital spending and R&D spending at home. The risk of losing global market access comes with opportunity costs. The ACC estimated that the shale gas revolution has led to 343 new chemicals industry projects as of February 2020,[187] which would equate to $203 billion in new capital investment in the U.S., 415,000 direct and indirect jobs by 2025, and nearly $300 billion in new output.[188] Tariffs and other policies that threaten exports undermine the cost advantages of serving global markets from a U.S. base, limit potential economic benefits for the U.S., and could create excess supply problems.

The chemicals industry is consistently one of the largest private-sector industry investors in U.S. R&D. Chemicals manufacturing generated $10.1 billion in U.S. R&D spending in 2019.[189] Basic and specialty chemicals companies typically allocate 2% to 3% of annual sales to R&D.[190]

Unlike many other manufacturing industries that receive government funding for research, the U.S. chemicals industry largely funds R&D on its own dime, with the exception of partial benefit from the federal R&D tax credit. A March 2020 National Science Board report showed 91.8% of chemicals manufacturers self-funded their R&D.[191] U.S. basic and specialty chemicals producers put half (53.5%) of R&D spending toward development, 34% toward applied research, and 8.5% toward basic research in 2018. Globally, U.S. firm R&D is second only to China (see Figure 4-5).

Figure 4-5: Business R&D Expenditures in Chemicals and Chemical Products Industries by Country, 2016
Purchasing power parity billions of current dollars



Source: U.S. National Science Board.

186 Profit margin refers to return on equity. American Chemistry Council, "2019 Guide to the Business of Chemistry," June 2019, p. 15. https://store.americanchemistry.com/products/guide-to-the-business-of-chemistry-2019-electronic-version-copy

187 Includes completed, started, and potential chemical industry projects.

188 American Chemistry Council, "Shale Gas Is Driving New Chemical Industry Investment in the U.S.," February 2020. https://www.americanchemistry.com/Policy/Energy/Shale-Gas/Fact-Sheet-US-Chemical-Investment-Linked-to-Shale-Gas.pdf

189 Ibid.

190 American Chemistry Council, "2019 Guide to the Business of Chemistry," June 2019, p. 50. https://store.americanchemistry.com/products/guide-to-the-business-of-chemistry-2019-electronic-version-copy

191 Mark Boroush, "Research and Development: U.S. Trends and International Comparisons," National Science Board, January 15, 2020. https://ncses.nsf.gov/pubs/nsb20203

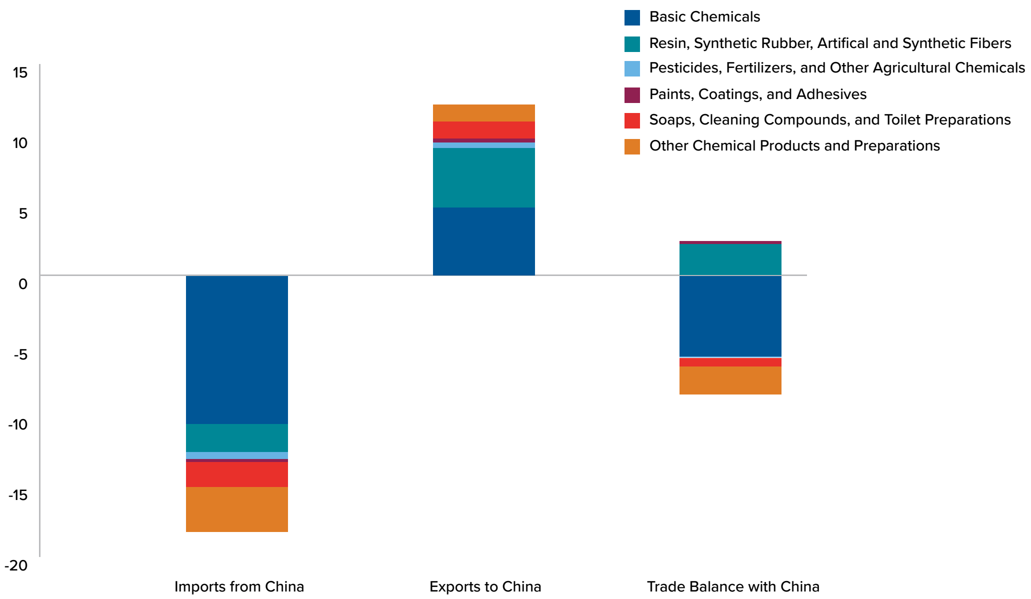
U.S.-CHINA ENGAGEMENT

China is critical to the U.S. chemicals sector in four ways: as a sales market; as a manufacturing base; as a source of raw materials; and as an R&D hub.

China is the single biggest chemicals market in the world by a wide margin, importing $189 billion worth of chemicals in 2018 and accounting for 13% of total world chemicals imports.[192] China is the third biggest market for U.S. chemicals after Canada and Mexico, consuming $10 billion in U.S. exports in 2019, or 7.4% of total U.S. chemicals exports. Crucially, given the importance of global supply chains in the industry, 37% of U.S. chemicals exports to China are to U.S. foreign affiliates, as are 31% of U.S. chemicals imports from China.[193] The OECD's 2018 data show that 92% of U.S. chemicals exports to China are intermediate products for use in processing or as manufacturing inputs, with 8% for household consumption. Fourteen percent of U.S. chemicals imports from China are for consumers, and 86% are used as intermediates.

China is not only one of the biggest markets for U.S. chemicals, but also the world's largest chemicals manufacturer and a top source of U.S. chemicals imports. China is the second biggest supplier to the U.S. chemicals industry, accounting for 11% of total imports in 2019. In most subcategories, China accounts for more than 10% of total U.S. imports from the world and nearly 20% of organic chemicals imports. As Figure 4-6 shows, the bulk of U.S. chemicals imports from China are basic chemicals, used as raw materials, resulting in a U.S. trade deficit in that category and in overall chemicals trade with China.

Figure 4-6: U.S. Chemicals Trade by Product Segment, 2018
USD billion



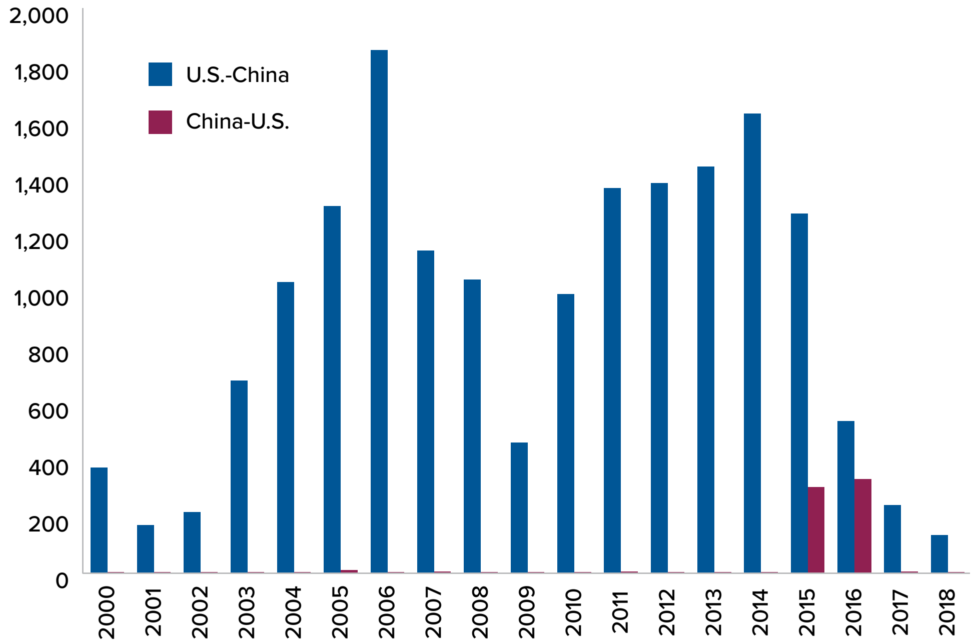
Source: U.S. Census Bureau. Based on NAICS codes 3251, 3252, 3253, 3255, 3256, and 3259.

192 American Chemistry Council, "2019 Guide to the Business of Chemistry," June 2019.
https://store.americanchemistry.com/products/guide-to-the-business-of-chemistry-2019-electronic-version-copy

193 American Chemistry Council, "Rebuttal Comments 'Proposed Modification of Action Pursuant to Section 301: China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation,'" July 3, 2019
https://www.americanchemistry.com/Trade/ACC-Section-301-Rebuttal-Comments-USTR-List-3-July-2019.pdf

Chemicals manufacturing is capital intensive, and the U.S. FDI footprint in China reflects that fact. From 2000 to 2018, cumulative U.S. chemicals industry FDI transactions in China totaled nearly $20 billion, making it a top sector for U.S. investment in China by value. Figure 7 shows annual U.S. FDI in China slowing after the global financial crisis, then ramping up after Beijing stimulated heavily. Transactions have fallen in recent years as supply rose and demand flagged, dampening margins. U.S. firms have facilities for both chemicals and plastics in China.[194] Chinese FDI in U.S. chemicals is smaller, totaling only $650 million over the same period. Recent transactions were motivated by access to affordable U.S. energy products.

Figure 4-7: U.S.-China FDI Transactions in the Chemicals Industry, 2000-2018
USD million



Source: RHG calculations.

Continuously deepening the capital stock is critical to U.S. chemicals industry competitiveness. The scale of global sales determines how much companies can allocate to capital investment. In 2019, the U.S. chemicals industry invested 6% of its annual shipments, or $35.1 billion, on capital expenditure. Access to the China market is an important factor driving investment decisions of U.S. chemical companies. As tensions and costly trade barriers have risen, continued access to China's market is uncertain. If 7% (China's share) of total U.S. chemicals exports are at risk from losing market access, U.S. companies would not commit to continued capital deepening. Some segments of U.S. chemical products, such as basic chemicals, can be substituted by suppliers from other countries relatively easily. Given high substitutability in lower-value-added chemicals, if the U.S. decouples with China on a bilateral basis, the vacuum could be quickly filled by its competitors. This dynamic has already played out in the case of German manufacturer BASF's $10 billion petrochemicals project in Guangdong, which started construction in late 2019 and will bring capacity online starting in 2022.[195] The project, hailed by Premier Li Keqiang as a sign of China's further opening up, is linked to China's Belt and Road Initiative deepening trade and infrastructure connectivity with neighboring countries. In this respect, the U.S. chemicals sector risks experiencing an erosion of domestic chemicals production for China or other countries that maintain robust trading relationships with China.

194 Rhodium Group and National Committee on U.S.-China Relations, "The U.S.-China Investment Hub."

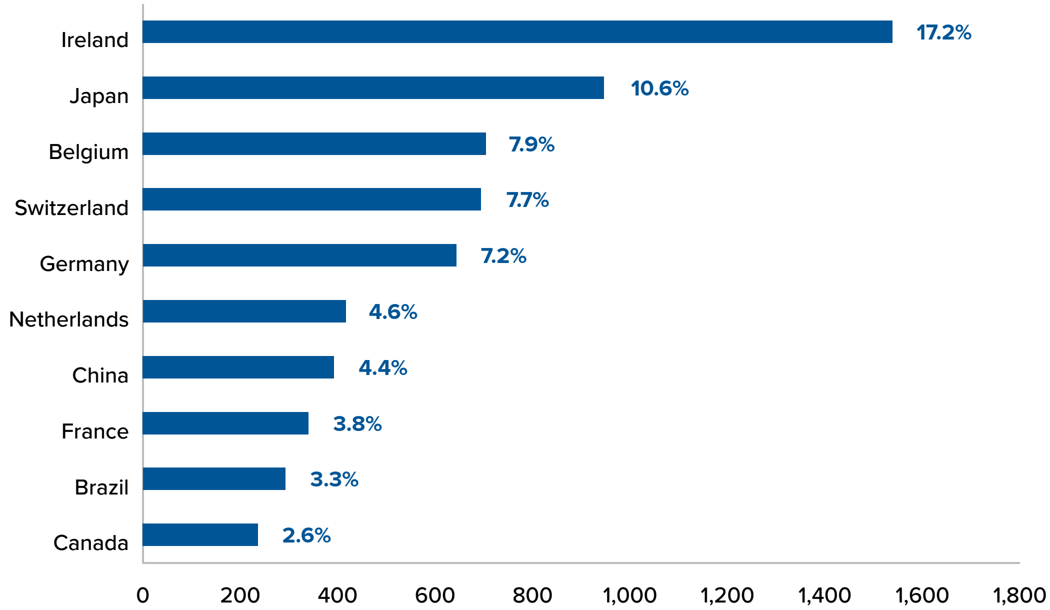
195 Reuters, "Germany's BASF Starts Building $10-Billion Petrochemical Project in China," November 23, 2019. https://www.reuters.com/article/us-china-basf-petrochemicals-guangdong/germanys-basf-starts-building-10-billion-petrochemical-project-in-china-idUSKBN1XX06S

China has the world's highest chemicals R&D spending, making it an important talent pool draw for multinationals, including those from the U.S. (Figure 4-8). U.S. foreign affiliates in China spent nearly $400 million on R&D in 2017, accounting for 4.5% of total U.S. R&D spending on chemicals abroad, on par with Switzerland.[196] Domestic firm R&D in China was concentrated historically in bulk chemicals, with foreign multinationals dominating specialty and higher-end segments.[197]

Most important to U.S. industry is the role that China R&D plays as an enabler of global R&D and collaboration. Oxford Economics estimated that R&D spending in the Asia Pacific region (the majority of which comes from China) supported $40 billion in GDP and 1.1 million jobs there.[198] R&D conducted locally is not independent of global efforts but rather is often integrated globally, so that money spent on R&D in China generates spillover effects in other markets.

Figure 4-8: Chemicals Manufacturing R&D Expenditure by U.S. Majority-Owned Foreign Affiliates by Country*

USD million in 2017, and percentage of total industry R&D expenditure abroad



Source: U.S. BEA. *Chemicals manufacturing (NAICS 325) includes pharmaceuticals; no further breakdown available.

ANALYSIS: WHAT ARE THE COSTS?

The economics of the chemicals manufacturing industry mean that manufacturing is both capital- and energy-intensive, low-margin on average, and dependent on global trade and manufacturing. China is an important market for U.S. industry; given thin margins and the importance of scale economies, small cost increases in even a minor link in the supply chain can make a player uncompetitive. Based on our industry stakeholder interviews, the biggest U.S.-China decoupling impacts would arise from trade disruption for chemicals and downstream manufactured products. U.S. exports for final use and intermediate processing in China would be disrupted, including flows to U.S. affiliates manufacturing in China purely for local use.

196 U.S. Bureau of Economic Analysis data.

197 KPMG, "China's Chemical Industry: The Emergence of Local Champions," October 9, 2013. https://assets.kpmg/content/dam/kpmg/pdf/2013/10/China-Chemical-Industry-201310.pdf

198 Oxford Economics, prepared for International Council of Chemical Associations (ICCA), "The Global Chemical Industry: Catalyzing Growth and Addressing Our World's Sustainability Challenges," March 2019, p. 24. https://www.oxfordeconomics.com/recent-releases/the-global-chemical-industry-catalyzing-growth-and-addressing-our-world-sustainability-challenges

U.S. IMPORT TARIFFS

U.S. tariffs threaten firms at home that use inputs from China. The first three rounds of Washington's tariff escalation covered $250 billion in imports from China—overwhelmingly intermediate inputs going into U.S. manufacturing. This impairs U.S. manufacturing relative to nontariffed competitors. U.S. chemicals and plastics were largely spared from the initial ($34 billion) round, but more than half the tariff lines in the second ($16 billion) round hit them (affecting goods valued at $2.2 billion in 2017). The third round (on $200 billion, effective September 2018) affected thousands of chemicals and plastics products valued at $13.2 billion in 2018.[199] Out of 141 U.S. chemicals product imports from China subject to tariffs, China was the sole source of imported supply for 44 products.[200] Table 4-1 summarizes the Section 301 tariffs impact on chemicals.

Table 4-1: U.S. Tariff Coverage of U.S. Chemicals Industry Imports from China
2018 values, USD million, percentage

Product Category	Value of Imports from China	Tariff Coverage of Imports from China	Tariff Coverage of Imports from the World
Inorganic Chemicals, Rare Earths, Radioactive Compounds	1,676.4	52.1%	6.8%
Organic Chemicals	9,744.4	31.4%	5.7%
Fertilizers	61.1	61.9%	0.6%
Tanning and Dye, Paint, Putty, Inks	672.8	61.1%	9.3%
Essential Oils, Perfumes, Cosmetic Preparations	1,565.5	84.4%	8.9%
Soaps, Waxes, Polish, Candles	539.5	64.4%	9.6%
Albuminoidal Substances, Modified Starch, Glue, Enzymes	362.2	95.4%	13.1%
Explosives, Pyrotechnics	357.0	5.5%	2.1%
Photographic or Cinematic Goods	27.8	49.3%	0.8%
Miscellaneous Chemical Products	1,727.7	52.0%	6.1%

Sources: U.S. BEA, USTR, RHG calculations. Classification based on Harmonized System (HS) chapters 28-38 but excludes pharmaceutical products. Effective tariffs rates as of end-2019. Only reflects new China tariffs under Section 301 and not preexisting or additional tariffs.

U.S. companies indicated how U.S. import tariffs would affect their businesses in an anonymized ACC publication.[201] It described hard decisions: faced with higher input and sourcing costs, many manufacturers paid millions of dollars in duties, leaving them no choice but to raise prices and pass on costs to consumers. In many cases there is no domestic production and a relocalization of imports would require two to three years at a minimum. Even where alternative suppliers to China exist, it can take years and significant expenditures for new vendors to meet quality and technical specifications. As a result of these pressures, some U.S. manufacturers are shifting jobs, deferring investments or switching them to other regions, or—particularly for small and medium enterprises operating on thinner margins—simply closing U.S. facilities.

On net, the biggest implication is that U.S. import tariffs diminish the competitiveness of U.S. manufacturers. As the price of doing business with U.S. companies rises under tariffs, foreign competitors simply become lower-cost suppliers in global supply chains.

199 American Chemistry Council, "An Assessment of the Impact of Retaliatory Tariffs on U.S. Chemical Exports to China: Jobs Lost and Economic Harm," October 2018, https://www.americanchemistry.com/Policy/Trade/An-Assessment-of-the-Impact-of-Retaliatory-Tariffs-on-US-Chemical-Exports-to-China.pdf.

200 Ibid.

201 American Chemistry Council, "Firsthand Account of the Impact of China Section 301 Tariffs on US Chemicals Manufacturers," September 25, 2018. https://www.americanchemistry.com/Policy/Trade/Firsthand-Accounts-of-the-Impact-of-China-Section-301-Tariffs-on-US-Chemicals-Manufacturers.pdf

CHINA'S RETALIATORY TARIFFS

Retaliatory tariffs could be the biggest factor in decoupling economics for the chemicals industry. In the long term, U.S. manufacturers' global competitiveness will depend heavily on access to the large and growing Chinese market. Retaliatory tariffs in China push up prices on U.S. goods and negatively impact demand for those products. The tariffs artificially inflate the price of U.S. chemicals exports to China and inflate the prices of other U.S. goods that incorporate U.S.-made chemicals as inputs. The negative impact from the loss in Chinese import demand to the U.S. chemicals manufacturing industry is both direct and indirect in this manner. The loss in U.S. export sales to China depends on how "elastic" China's demand is, or whether there are substitutes. Indeed, China has attempted to increase the availability of substitutes by reducing tariffs on imports from other countries. The Peterson Institute notes that, throughout 2018, China lowered tariffs on imports from all other WTO members, including reducing duties on 1,585 industrial products, including chemicals.[202]

The presence of bilateral tariffs and China's tariff reductions for non-U.S. partners mean U.S. companies are at a competitive disadvantage for selling to China, and in easily substitutable segments this disadvantage would compel purchasers in China to find alternatives to U.S. supply (all else equal). In October 2018, the ACC published a study estimating the impact of retaliatory tariffs from China. They simulated two scenarios. In the high-substitution scenario U.S. exports fall by $6.1 billion annually; in the baseline case China is not easily able to substitute for U.S. products in the near term, so U.S. chemicals and plastics exports to China fall "just" $1.6 billion annually.[203] This baseline scenario illustrates what might happen in the very short term, where importers have not had enough time to navigate to alternative suppliers. By continuing to liberalize trade with other non-U.S. partners, particularly from the Asia Pacific, the Chinese government has accelerated the pace of this scenario becoming reality. As a result, alternative suppliers are becoming cheaper—and the more extreme scenario becomes more likely.

In the first three rounds of China's retaliatory tariffs, U.S. chemicals and plastics product exports to China worth $10.8 billion annually were exposed to tariffs ranging from 5% to 25%.[204] The resulting loss in demand for U.S. chemicals would reduce the competitiveness of U.S. chemicals manufacturers and result in losses to output and jobs. The ACC estimated that 8,000 jobs in the U.S. chemicals industry could be lost due to lower Chinese demand for U.S. chemicals.[205] Upstream, suppliers of inputs and services to the U.S. chemicals industry would face reduced demand. Finally, indirect losses in purchases made by suppliers to the U.S. chemicals industry could put 46,000 more jobs on the line. In total, retaliatory tariffs put 55,000 U.S. jobs and $18 billion in domestic activity at risk.[206]

CALCULATING COSTS: APPROACH AND ESTIMATIONS

We augment the ACC's findings on 2018 tariff impacts by adding China's fourth-round tariffs (implemented September 2019) and adding a more detailed breakdown by segment. We extend losses from the first three tariffs rounds with some assumptions: first, that an increase in tariffs on U.S. exports results in a commensurate decrease in output; and second, that the jobs and payroll associated with decreased output remain constant—that is to say, a loss in output under additional tariffs would reduce jobs and payroll by the same proportion. These assumptions are not based on actual jobs, payroll, and output associated with specific products or segments, but they do allow a projection of the costs to the U.S. chemicals industry and economy. In addition, we do not consider differential impacts of specific tariff rates.[207]

202 Peterson Institute for International Economics, "Trump Has Gotten China to Lower Its Tariffs. Just toward Everyone Else," June 2019. https://www.piie.com/blogs/trade-and-investment-policy-watch/trump-has-gotten-china-lower-its-tariffs-just-toward

203 American Chemistry Council, "An Assessment of the Impact of Retaliatory Tariffs on U.S. Chemical Exports to China: Jobs Lost and Economic Harm," October 17, 2018. https://www.americanchemistry.com/Policy/Trade/An-Assessment-of-the-Impact-of-Retaliatory-Tariffs-on-US-Chemical-Exports-to-China.pdf

204 Ibid.

205 Ibid.

206 Ibid.

207 China's tariffs in the fourth round ranged from 5% to 25% until rates were reduced ahead of the U.S.-China Phase One trade deal signed in February 2020.

By our estimation, 31% of the *value* of U.S. chemicals and plastics product exports to China were subject to China's retaliatory tariffs at the end of 2018 (for comparison with the ACC study, we add to chemicals plastics and products thereof).[208]

In extending the ACC's impact study results, we first look at where China raised additional tariffs in 2019. Because China could not match U.S. tariff escalation with tit-for-tat retaliation, its 2019 tariffs applied higher tariff rates on products already subject to earlier rounds of tariffs in 2018. For that reason, we consider only marginal tariffs—the addition of tariffs on U.S. exports to China that weren't already tariffed.

As Table 4-2 shows, China's August 2019 tariffs applied to nearly all U.S. exports to China in nine out of 11 product categories considered in this analysis. For some products, like fertilizers, China is a minor export market, accounting for less than 2% of U.S. exports to the world, so the impact of 100% tariff coverage is negligible. However, in other sectors, such as organic chemicals, where 9% of total U.S. exports go to China, 95% are subject to tariffs.

Table 4-2: U.S. Chemicals Exports to China Subject to China's Tariffs as of 2019 (All Four Rounds)
USD billion, 2018 trade values

	Exports to China	Exports to World	Exports to China Subject to Tariffs	Share of Exports to China Subject to Tariffs	Share of Exports to World Subject to China Tariffs
Inorganic Chemicals, Rare Earths, Radioactive Compounds	1.0	12.5	1.0	97%	8%
Organic Chemicals**	3.9	40.3	3.7	95%	9%
Fertilizers	0.0	4.2	0.0	100%	1%
Tanning and Dye, Paint, Putty, Inks	0.5	8.0	0.5	100%	6%
Essential Oils, Perfumes, Cosmetic Preparations	1.3	13.6	1.3	100%	10%
Soaps, Waxes, Polish, Candles	0.9	7.3	0.9	100%	12%
Albuminoidal Substances, Modified Starch, Glue, Enzymes	0.5	3.6	0.5	100%	14%
Explosives, Pyrotechnics	0.0	0.8	0.0	100%	5%
Photographic or Cinematic Goods	0.6	2.2	0.5	90%	24%
Miscellaneous Chemical products	3.8	30.3	1.2	31%	4%
Plastics and Products	7.1	66.6	3.0	43%	5%
Subtotal: Chemicals*	**12.6**	**122.7**	**6.2**	**49%**	**5%**
Total Chemicals and Plastics Products	**19.6**	**189.3**	**12.7**	**65%**	**7%**

Sources: State Council, Census, MOFCOM. U.S. exports to China and U.S. exports subject to Chinese tariffs are based on values reported by China Customs for better comparability. *Chemicals includes HS chapters 28-38 but does not include pharmaceuticals. Plastics and products includes HS chapter 39. See methodology appendix for details. **China exempted some organic chemicals from tariffs in September 2018.

208 Discord between trade classification systems means that value may be overstated. See methodology appendix for details.

Our approach determines the share of U.S. chemicals and plastics exports subject to retaliatory Chinese tariffs in all four rounds (through end-2019).[209] We assume the percentage increase in tariff coverage results in a commensurate decrease in output, payroll, and jobs under the two scenarios.

Table 4-3 summarizes our results under the various assumptions. The potential hit ranges from $10.2 billion in U.S. payroll and output reductions and 26,000 in job losses (if China has a hard time substituting for U.S. products in the near term) to more than $38 billion in losses and nearly 100,000 jobs at risk in the longer term if China succeeds in quickly establishing substitutes.

Table 4-3: Estimated Impacts of China's Retaliatory Tariffs (2019) on U.S. Chemical and Plastics Industry and U.S. Economy
2018 values

	Jobs at Risk		Lost Payroll (Billion)		Lost Output (Billion)	
Impact Type	Relatively Inelastic Response, Near Term	Relatively Elastic Response, Longer Term	Relatively Inelastic Response, Near Term	Relatively Elastic Response, Longer Term	Relatively Inelastic Response, Near Term	Relatively Elastic Response, Longer Term
Direct (Chemicals and Plastics)	3,916	14,864	0.4	1.3	2.9	11.0
Indirect (Supply Chain)	10,889	41,355	0.9	3.2	3.8	14.1
Payroll-Induced Spending	11,097	42,141	0.5	2.2	1.8	6.9
Total Impact	**25,902**	**98,360**	**1.8**	**6.7**	**8.5**	**32**

Sources: U.S. BEA, Federal Reserve, ACC, China Customs tariffs and trade levels in 2018.

INTERPRETATION: WHAT DOES IT MEAN FOR THE U.S. ECONOMY?

China is projected to account for over half of the global chemicals industry's growth in the coming decade, and rebalancing to household demand means higher consumer products growth.[210] That is where U.S. leadership is greatest; thus, decoupling means for U.S. industry a smaller share of a growing pie. There are reasons to doubt the smoothness of China's transition to a consumer-driver economic model. The ratio of income to debt has trended in a worrying direction over the past decade. But in the long term there is little doubt that a major portion of marginal global consumer chemical demand growth will arise from China. If tariffs on U.S. chemicals remain in place as China continues to invest and grow its consumer base, chemical buyers in China will likely turn to Europeans and other non-U.S. competitors to participate in that growth at the expense of U.S. industry. China will also be incentivized to invest in creating and expanding Chinese domestic production.

Tariffs erode the competitiveness of U.S. manufacturers by incentivizing offshoring and trade diversion. With already low margins, lost economies of scale and scope (inherent to any decoupling strategy) will reduce the absolute and relative competitiveness of U.S. firms in this sector, in terms of their position in the Chinese market but also in terms

209 See methodology appendix for discussion of limitations of comparing U.S. tariff lines with China's trade classification system.

210 Sheng Hong et al., "China's Chemical Industry: New Strategies for a New Era," *McKinsey and Company*, March 2019. https://www.mckinsey.com/industries/chemicals/our-insights/chinas-chemical-industry-new-strategies-for-a-new-era

of their competitiveness in third markets and even—given sourcing costs—at home in the U.S. The U.S. is a highly desirable production base for chemicals companies due to its competitively priced raw materials costs, strong IP protections, and a mature operating environment; tariffs undermine such competitive advantages.

European competitors have already taken advantage of U.S.-China tensions and are building new capacity in China. Additionally, China-European trade should increase given China's lowering of tariffs on European products. In some segments the U.S. is replaceable despite being an industry leader. Some chemicals are homogenous, and subtle cost advantages, process efficiencies, and—perhaps most of all—the ability of company executives to make strategic corporate decisions in a predictable political environment are crucial for determining which firms survive and which do not.

The costs of decoupling are not easily mitigated. The chemicals industry is capital intensive, and plants and equipment are not easily moved around to adjust to uncertain policies. The industry operates at low profit margins, and higher operating costs from tariffs or other market distortions must be made up through lower dividends, lower spending on business development and R&D, or other measures. Unlike in China, industrial firms in the U.S. are judged on a daily basis by the marketplace, on stock exchanges and debt markets, and will be penalized for these decisions. It is worth remembering that 29 of the 30 original Dow Industrial Index companies have gone out of business over the years (and GE, number 30, has had to sell off many assets and go through wrenching adjustments). Many U.S. chemicals industry leaders have formally requested exclusions from the Section 301 tariffs, and despite laying out the economic costs in terms of lost U.S. output, lost U.S. jobs, and lost competitiveness, few exclusions have been granted.

Decoupling is not happening in a vacuum; the global chemicals industry faces serious cyclical headwinds. Many segments are saddled with overcapacity (not least due to China), and planned investment expenditures were already on hold pre-COVID-19. Consolidation was already underway in some segments. With the confluence of downside risks from oversupply and the COVID-19 hit to global demand, the importance of this industry is more critical to the U.S. economy than ever. In this respect, decoupling in the chemicals industry could be a cure worse than the disease it is meant to fix.

Medical Device Industry

INDUSTRY SNAPSHOT

Medical devices include a wide range of products, from common everyday medical supplies, such as latex gloves and syringes, to sophisticated equipment with advanced technologies, such as magnetic resonance imaging (MRI) and computed tomography machines. The U.S. is a global leader in the medical device industry in many ways. As the world's largest medical devices market, the U.S. accounted for 40% of global demand ($156 billion) in 2017.[211] U.S. exports in this industry were $43 billion in 2018, directly supporting 300,000 U.S. jobs and indirectly 2 million jobs, as medical device manufacturing supports downstream suppliers of components like spectrometers, sensors, and generators, and materials such as rubber, textiles, and plastics.[212] U.S. firms lead global innovation in medical devices due to significant investment in R&D: U.S. medical device makers spend 7% of revenue on R&D on average, well above other U.S. industries with high R&D intensity, such as autos and telecommunications.[213]

211 SelectUSA, "Medical Technology Spotlight," accessed June 2020.
https://www.selectusa.gov/medical-technology-industry-united-states

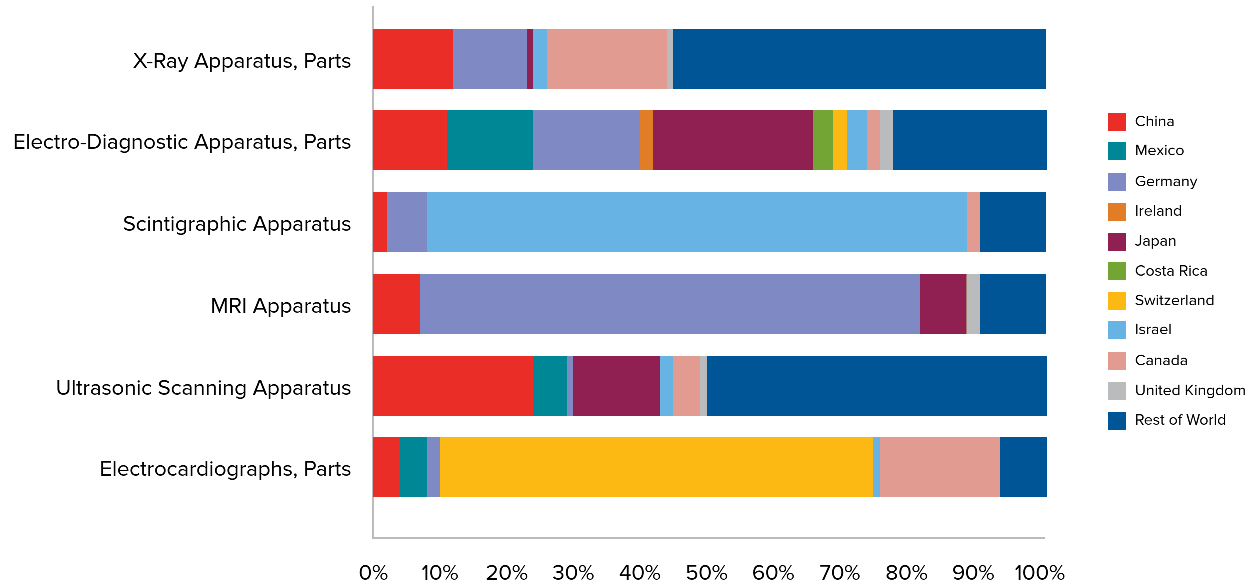
212 Ibid.

213 The Advanced Medical Technology Association, "Submission of Ralph F. Ives on Behalf of the Advanced Medical Technology Association to the Committee on Section 301," June 17, 2019.
https://www.documentcloud.org/documents/6186869-AdvaMed-Section-301-Testimony-June-2019-Final.html;
SelectUSA, "Medical Technology Spotlight," accessed June 2020.
https://www.selectusa.gov/medical-technology-industry-united-states

U.S.-CHINA ENGAGEMENT

Reflecting the strength of the U.S. medical device sector, most of the U.S. domestic medical devices market is supplied by products that are made in the U.S. or made by U.S.-based companies, except in some smaller and less advanced segments of the market such as disposables. U.S. manufacturers of advanced medical devices rely on global supply chains to source the lower-value-added inputs that go into high-value production and exports. The U.S. supplier base is diverse. China is a supplier of medical devices and parts to the U.S., ranking among the top 10 in many categories, and in ultrasound scanners accounts for the biggest single-country share of U.S. imports by value (around 22% in 2018, as shown in Figure 5-1). However, compared to China, Japan and Germany are far bigger suppliers of medical devices and parts to the U.S., as are Israel and Switzerland, which account for more than 60% of U.S. imports of certain diagnostic tests and electrocardiogram machines. Although trade statistics do not reflect the complexity of advanced medical device supply chains, they reflect that China is not a dominant supplier of medical devices to the U.S., especially at the more complex end of the market, where it ranks not only behind U.S. domestic suppliers but also behind other countries, and that exposure to China is mitigated by an integrated supply chain with sourcing partners across different continents in Europe, Asia, and Latin America. While China is a big player in certain segments, it is the source for only 3.3% of U.S. medical device imports overall, according to the Advanced Medical Technology Association.[214]

Figure 5-1: Country Share of Select U.S. Medical Device Imports by Product Category, 2018
Percentage of USD value



Sources: U.S. Census Bureau, RHG calculations. Selected products in HS 9018. ROW means "rest of world."

214 United States International Trade Commission, "Submission to the International Trade Commission Investigation, No 332-580, COVID-19 Related Goods: U.S. Industry, Market, Trade & Supply Chain Challenges," *The Advanced Medical Technology Association and AdvaMed*, August 21, 2020. https://www.usitc.gov/research_and_analysis/332_580_notice_08_21_2020sgl.pdf

By contrast, China's domestic market depends on imported high-end medical devices ($22 billion in 2018) from foreign firms such as GE, Phillips, and Siemens.[215] Roughly 28% of China's medical device demand is served by imports, predominantly high-end diagnostic and imaging equipment.[216] But China's imports of medical devices and parts also reflect trade between multinationals and their local affiliates in China, which enables firms to source less advanced or relatively inexpensive parts from China for manufacturing at home.

U.S. medical devices are in high demand thanks to a strong technological reputation: U.S. firms derive nearly 75% of China revenue from sales to large public hospitals there.[217] Hospital procurement is an important growth channel in China because hospitals and their customers attach value to best-in-class medical equipment instead of domestic-made products that compete on price. Some domestic competitors have made inroads thanks to advantages like subsidies in low-end devices and preferential procurement arrangements with hospitals, especially those with some form of government ownership, though they remain less competitive at the higher end.

OPPORTUNITIES AND CHALLENGES IN CHINA

China's medical devices market is the second largest in the world, ranking just behind the U.S. at $78.8 billion in 2018.[218] The China market has grown by double digits for over a decade, sustaining an average compound annual growth rate of 20% from 2014 to 2018, while the global medical devices market grew by 5.3% over the same period.[219] Over 70% of China market growth was fueled by hospital procurement.

Given its large, growing middle class and aging population, China is expected to maintain its current growth rate for years to come, and it is a priority market for the medical device industry worldwide.[220] Cumulative U.S. FDI in the sector from 1990 to 2018 was $17 billion—6% of all U.S. FDI to China.[221] Manufacturing in China benefits from lower production costs as well as better access to the local market. China-based manufacturing and R&D by U.S. firms serve both local and global markets.

Despite its huge growth potential, selling in the Chinese market presents challenges to foreign medical device firms. If U.S.-China decoupling escalates, these challenges, summarized below, could significantly and disproportionally impact the U.S. medical device industry.

215 Daniel Allen, "China's Medical Devices Market: A Must-Win Proposition," East West Bank, March 30, 2020.
https://www.eastwestbank.com/ReachFurther/en/News/Article/China-Medical-Market-A-Must-Win-Proposition

216 U.S. International Trade Commission, "Healthcare Resource Guide: China," October 2019.
https://2016.export.gov/industry/health/healthcareresourceguide/eg_main_108574.asp

217 Ibid.

218 Ibid.

219 Liu Mao, "Chinese Medical Device Industry Report," *Zhihu*, June 2019.
https://zhuanlan.zhihu.com/p/122386087;
Research and Markets, "Global Medical Devices Market Report 2019-2022: A $521+ Billion Opportunity Analysis," September 19, 2019.
https://www.globenewswire.com/news-release/2019/09/19/1918062/0/en/Global-Medical-Devices-Market-Report-2019-2022-A-521-Billion-Opportunity-Analysis.html

220 U.S. International Trade Commission, "Healthcare Resource Guide: China," October 2019.
https://2016.export.gov/industry/health/healthcareresourceguide/eg_main_108574.asp

221 Rhodium Group and National Committee on U.S.-China Relations, "The U.S.-China Investment Hub."

Import Substitution

To reduce dependency on imports, China has made high-end medical devices development a key priority. The revised MIC 2025 industrial policy roadmap identified certain high-end medical technologies for import substitution, as well as self-sufficiency goals (Table 5-1).

Table 5-1: Targeted High-End Medical Devices and Self-Sufficiency Goals under MIC 2025

Product Types	Goals		
Key high-end medical devices	2020	2025	2030
1. Medical imaging equipment 2. Clinical laboratory equipment 3. Advanced treatment equipment 4. Rehabilitation and medical monitoring devices	Use of domestic high-end medical devices in county hospitals up to 50%	Use of domestic high-end medical devices in county hospitals up to 70%	Use of domestic high-end medical devices in county hospitals up to 95%

Sources: The National Manufacturing Strategic Advisory Committee, MIC 2025 Implementation Roadmap.

Notably, the above goals target domestic product market share only in small county hospitals in rural areas. These hospitals are more cost sensitive and less in need of the most advanced medical devices.
To achieve these goals, Beijing has sought to create so-called national champions by providing funding and tax cuts to domestic manufacturers. Common forms of government support include the following:

- **Tax relief**: Companies developing indigenous IP for new electrophysiology and monitoring technologies are eligible for a reduced corporate income tax of 15%, as opposed to the standard 25%.
- **National R&D fund**: Digital diagnostic and treatment equipment is subsidized by the National R&D Fund. For example, Chinese company Mindray received RMB 15 million ($2.2 million) for the development of a three-dimensional ultrasound imaging system.

- **Industry investment fund**: Chinese company United Imaging received an RMB 166 million ($24.4 million) investment from Shanghai Alliance Investment, an investment fund owned by the Shanghai government.

Public Procurement

U.S. medical device firms derive nearly 75% of China revenue from sales to large public hospitals.[222] Even so, foreign medical device makers face compliance challenges with public hospitals' procurement process, which could disproportionally affect U.S. firms if decoupling escalates. Foreign medical device firms rely on one or more layers of local middlemen to sell to large hospitals. Hospitals often force manufacturers to sell through these middlemen, leaving firms exposed to bribery and corruption given high-volume, high-value equipment purchases. The cost of doing business in China in the medical device industry therefore includes compliance costs for firms navigating the procurement process.

Other than compliance costs, U.S. firms are also disadvantaged in the tendering process by policies favoring domestic medical devices. To promote import substitution, local governments have tried to influence public hospitals' purchase decisions in two ways. One is by setting local purchase targets. Purchase targets vary by region, but they can be as high as 80% for domestically or regionally made products.[223] Another is by reimbursing hospitals

222 Ibid.

223 Mohith Unny and Zaid Al-Nassir, "China's Medtech Goals," Decision Resources Group, October 30, 2019. https://www.meddeviceonline.com/doc/china-s-medtech-goals-0001

for local brand purchases.[224] Although U.S. and other cutting-edge foreign medical devices are still preferred in large hospitals in Tier-1 cities such as Beijing and Shanghai, where facilities are well resourced and health care standards higher, these policies could be scaled up in a way that would limit U.S. and other foreign access. However, these policies do not appear to conflict with China's trade commitments, since China is not currently a member of the WTO Government Procurement Agreement (though it pledged to join as part of its WTO accession in 2000), nor of other trade agreements with procurement commitments.

In addition, ongoing procurement reform to make health care more affordable in China could also bring significant challenges to U.S. medical device firms. The initiative, dubbed *volume-based procurement*, seeks to centralize bidding processes for all hospitals within the same province, allowing local governments to negotiate prices with medical device sellers. Beijing hopes that scaling up order size will drive prices lower, benefiting patients and potentially curtailing kickbacks and bribery.

This new procurement process, which first targeted high-value medical consumables (a category of medical devices that includes implantables but has expanded beyond that segment), is being tested in a few provinces. Anhui was the first province to centralize hospital procurement by asking its public hospitals to form a group purchasing organization in April 2019.[225] By July that year, local prices of orthopedics and ophthalmology devices had been reduced by 50% and 20%, respectively.[226] In November 2020, China conducted its first nationwide procurement for medical devices. The national tender for cardiac stents resulted in about a 60% price drop.[227]

The initiative does not have a stated goal of displacing or disadvantaging foreign devices. Nonetheless, it does mean U.S. medical device makers must rethink their sales and pricing strategies in China. As producers of high-quality equipment, U.S. firms may have a better chance at securing larger-volume orders than individual hospital orders; however, it is expected that U.S. device makers may not be as willing or able to slash prices to win bids, resulting in lost sales to domestic competitors.[228] The impact this reform will have on U.S. medical device makers remains to be seen.

ANALYSIS: WHAT ARE THE COSTS?

While the operating environment in China presents a challenge to U.S. medical device firms there, policies to decouple the U.S. and Chinese economies threaten the firms' presence in the Chinese market. Decoupling risks facing the U.S. medical device industry are twofold: efforts by the U.S. through tariffs or other supply chain initiatives make it more costly and difficult (or impossible) for U.S. medical device companies to draw on Chinese operations (including those owned by the same U.S. companies) as part of their global sourcing strategy, and efforts by China, including but not solely in retaliation, also make it more difficult (or impossible) for U.S. medical device makers to sell their products. The result could be significantly fewer exports in what has historically been one of the U.S.' most competitive export sectors, less money for investment by U.S. medical device makers to keep pace with European and Asian competitors, and higher costs for U.S. health care consumers.

224 Ibid.

225 Frances Wu, Abigail Higgins, and Angela Wang, "Changes in China: How Can Medtech Companies Succeed? (Part One)," Health Advances, November 11, 2019. https://healthadvancesblog.com/2019/11/11/changes-in-china-how-can-medtech-companies-succeed-part-one/

226 Ibid.

227 CGTN, "China Slashes Coronary Stent Prices through National Procurement," November 6, 2020. https://news.cgtn.com/news/2020-11-06/China-slashes-coronary-stent-prices-through-national-procurement-VclxkpU3Zu/index.html

228 Vale Wang, "The Impact of the Two-Invoice System and Volume-Based Procurement on Medical Device Companies," CN-Healthcare, October 22, 2019. https://www.cn-healthcare.com/articlewm/20191022/content-1073371.html

BILATERAL TARIFFS

One of the first U.S. moves toward decoupling, for medical devices as well as other sectors, came from the U.S. Section 301 tariffs on imports from China that were imposed in 2018 and remain in effect. Tariffs impose costs on U.S. companies' trade between business units with operations in China and the U.S., and therefore negatively impact the sales revenue earmarked for R&D spending needed to maintain a cutting-edge global lead.

It is hard to know exactly how much of the U.S. medical device sector has been affected by the Section 301 tariffs. As with many sectors subject to the Section 301 tariffs, it appears that the categories of medical devices for which the cost of 25% tariffs would be directly borne by the U.S. public—such as implantable devices—were generally kept off the Trump administration's tariff lists, while capital goods whose 25% tariff cost would be borne by U.S. hospitals, offices and clinics, and other institutions—which consequently would be less publicly visible—were included. Furthermore, many mechanical, electro-mechanical, and other parts and components used and imported by U.S. medical device makers are not reflected in trade data as specifically related to medical devices, making it hard to assess the degree to which corresponding imports of those products are related to the medical device sector (the WHO identifies over 22,000 generic groups of medical technologies and 2 million types of products, but the Harmonized Tariff Schedule system has only 120 lines for medical devices and diagnostics).[229] According to the Washington-based Advanced Medical Technology Association, there are at least 90 products on the USTR tariff lists that are identified as nonmedical technology products yet used in various medical technology products.[230]

U.S. import tariffs have multiple negative effects on the U.S. medical device industry. First, tariffs make U.S. imports of parts and components from China more expensive for U.S. medical device manufacturers. This cost increase is passed down to U.S. hospitals and ultimately to U.S. patients. A 2018 study published by the American Action Forum (AAF) found that the Section 301 tariffs announced in July 2018 on 55 specific medical device-related products would impact $1.8 billion in imports and increase medical equipment prices by roughly $400 million nationwide.[231] The AAF report also estimated that health care providers faced with higher costs for medical equipment would try to recoup those costs by charging higher prices to patients.[232]

Available data reflect the value of U.S. imports from China subject to tariffs in three specific categories of medical devices: diagnostic equipment, surgical instruments, and disposables. Data show that half of U.S. diagnostic equipment imports ($457 million annually) from China are subject to Section 301 tariffs, while 14% of surgical instrument imports ($123 million annually) and 11% of disposables ($111 million annually) from China are also covered.[233] Since COVID-19 hit the U.S. in March 2020, the USTR has reduced some Section 301 tariffs on specific products related to medical supply and equipment items from China, but determining which products and assessing their value is difficult given that such products can be used for a variety of end-products.[234]

Second, U.S. import tariffs reduce the competitiveness of U.S.-made medical devices relative to those made in third countries, such as European states or Japan, which have not paid tariffs on Chinese inputs. The U.S. tariffs particularly

229 Advanced Medical Technology Association, "Submission of Ralph F. Ives on Behalf of the Advanced Medical Technology Association to the Committee on Section 301," June 17, 2019. https://assets.documentcloud.org/documents/6186869/AdvaMed-Section-301-Testimony-June-2019-Final.pdf

230 Ibid.

231 Jacqueline Varas and Tara O'Neill Hayes, "How a Trade War with China Will Impact U.S. Health Care Costs," American Action Forum, July 12, 2018. https://www.americanactionforum.org/research/how-a-trade-war-with-china-will-impact-u-s-health-care-costs/

232 Ibid.

233 We adopt a classification used by the United States International Trade Commission (USITC) to identify products classified as medical devices. Using U.S. Census Bureau trade data, we sum U.S. imports of those goods subject to U.S. Section 301 tariffs as identified by USTR as of end-2019. Mihir P. Torsekar, "China's Changing Medical Device Exports," U.S. International Trade Commission, January 2018. https://www.usitc.gov/publications/332/journals/china_medtech_jice_508_compliant-error.pdf

234 Karen M. Sutter et al., "COVID-19: China Medical Supply Chains and Broader Trade Issues," Congressional Research Service, October 8, 2020. https://crsreports.congress.gov/product/pdf/R/R46304

affected U.S. multinational firms with manufacturing and supply chains passing through China.[235] In this sense, manufacturers have been put at a competitive disadvantage both at home and abroad. Although increased costs due to tariffs may incentivize U.S. manufacturers to move sourcing from China to other countries that were not previously considered as optimal options, this move also diminishes the U.S. presence in and access to China's massive and growing market.

Third, shouldering the costs of U.S. tariffs and decreasing presence in the China market diminish the funds U.S. manufacturers have available to invest in new technologies and facilities. Higher input costs from tariffs and supply chain restructuring, as well as lower revenue from forgone access to China's market, squeeze profit margins, giving some U.S. medical device manufacturers no choice but to hold off on R&D spending, which impedes U.S. technology leadership and reinforces a vicious cycle. In a letter to the USTR, the Medical Imaging and Technology Alliance reported that "100% of medical imaging manufacturers said they would invest fewer resources in research and development, and 100% said they would reduce workforce if the tariffs were put into effect."[236]

Not only do U.S. manufacturers face the increased costs and diminished competitiveness that naturally accompany tariffs on parts and components from China, they also face higher costs from China's retaliatory tariffs on medical equipment (for those exporting to U.S. affiliates in China) and higher, less competitive prices for their products in the Chinese market given the tariff markup. While China reduced tariffs on some U.S. exports during Phase One agreement negotiations—such as on aircraft and autos—China did not exempt U.S. medical technology exports. Because the U.S. and China use different product classification systems, it is difficult to determine the total amount of U.S. exports to China that are subject to retaliatory tariffs. However, retaliatory tariffs implemented in 2018 and 2019 affected nearly 100% of U.S. medical device exports to China.[237, 238]

U.S. INITIATIVES TO RESHORE SUPPLY CHAINS

The COVID-19 crisis generated new pressures from the Trump administration and members of Congress to produce more medical equipment in the U.S. and less in China.

Since the COVID-19 outbreak, there have been moves to restrict U.S. federal procurement, including of medical equipment, to U.S. suppliers. On July 27, 2020, Sen. Lindsey Graham (R-SC) introduced the Restoring Critical Supply Chains and Intellectual Property Act, which would require low-end medical equipment (mainly personal protective equipment and other textiles) purchased by the Department of Health and Human Services (HHS) to be completely domestically sourced within five years.[239] The fiscal year 2021 National Defense Authorization Act (NDAA) includes provisions requiring reports on medical equipment supply chains as well as pharmaceutical and other related products.[240] Although these proposals are not yet law, they reflect legislative momentum to reshore U.S. medical supply chains.

On August 6, 2020, former President Trump signed Executive Order (EO) 18012 on "Combating Public Health Emergencies and Strengthening National Security by Ensuring Essential Medicines, Medical Countermeasures, and Critical Inputs Are

235 Mary E. Lovely and Yang Liang, "Trump Tariffs Primarily Hit Multinational Supply Chains, Harm US Technology Competitiveness," Peterson Institute for International Economics, May 2018. https://www.piie.com/system/files/documents/pb18-12.pdf

236 Medical Imaging and Technology Alliance, "China 301 Public Comments," May 10, 2018. https://www.medicalimaging.org/wp-content/uploads/2018/07/MITA-China-Tariffs-ltr.pdf

237 Brock R. Williams and Keigh E. Hammond, "U.S.-China Tariff Actions by the Numbers," Congressional Research Service, October 9, 2019, p. 8. https://fas.org/sgp/crs/row/R45949.pdf

238 Conor Hale, "Trade War Tariffs Now Touch Nearly Every U.S. Medical Device Sold in China," FierceBiotech, September 25, 2018. https://www.fiercebiotech.com/medtech/trade-war-tariffs-now-touch-nearly-every-u-s-medical-device-sold-china

239 "Restoring Critical Supply Chains and Intellectual Property Act," S. 4324, 116th Congress 2020. https://www.congress.gov/bill/116th-congress/senate-bill/4324/text

240 National Defense Authorization Act for Fiscal Year 2021, H.R. 6395, 116th Congress (2019-2020), Sections 712 and 750L. https://www.congress.gov/bill/116th-congress/house-bill/6395/text

Made in the United States."[241] Much of the focus of this EO is on withdrawing federal procurement (principally by the Department of Veteran Affairs, Department of Defense, and Department of Health and Human Services) of the affected medical products from U.S. trade obligations, which does not affect China because the U.S. and China have no government procurement obligations to each other, bilaterally or through the WTO. However, the intent of the EO is also to make it harder for federal entities to obtain waivers via the Buy American Act to purchase these goods from other suppliers, such as China.

In addition, there has been talk in 2020, in the wake of the COVID-19 pandemic, of the U.S. government potentially withdrawing from the WTO Agreement on Government Procurement (GPA) altogether, with the experience of the pandemic cited as one rationale (though the impact of withdrawal would cut across all sectors, not just medical devices and technologies). Because China is not currently a party to the GPA—although it has engaged in long negotiations to accede—China would not be directly affected by U.S. withdrawal. That said, China would be indirectly affected in a few ways. First, should the U.S. withdraw from the GPA, it may reduce China's barrier to entry, since the U.S. has historically made strong demands of China to accede to that agreement (though the European Union [EU] would still require some commitments from China). Second, if China were to accede to the GPA, its exporters would potentially enjoy greater access to GPA members' government procurement than U.S. exporters would, should other GPA members follow through on their threats to bar U.S. products from their government procurement if the U.S. were to withdraw from the GPA. Under that scenario China would win new access for its exporters to the government procurement of GPA members, which includes many of the world's largest economies, such as the EU and its members, Japan, the United Kingdom, Canada, Korea, Taiwan, and others. Finally, a U.S. withdrawal from the GPA, or even a move to renegotiate commitments under the Buy American EO, could damage U.S. exports to third markets where government-owned health care institutions occupy a very large share of the market. The lack of competition from the U.S. in those markets would be an advantage to competitors from China and the rest of the world.

RISK OF ESCALATION FROM CHINA

If the U.S. continues to implement measures that encourage or compel U.S. medical device manufacturers to move their supply chains out of China and curtail imports from China, Beijing could respond not merely with tit-for-tat tariff retaliation but by instructing its public hospitals to stop purchasing U.S. medical devices, as well as slowing or stopping the regulatory approvals for U.S.-made medical devices. The U.S. is not the only global producer of medical devices, or even high-value medical devices. For those segments of the medical device industry where foreign technologies or brands remain popular in China, Beijing could instruct its medical institutions to turn to other advanced economy suppliers, such as the EU and Japan, at the expense of U.S. companies (a response to U.S. trade pressure that European vendors are reportedly already proposing to Chinese customers as part of their sales pitch). In such circumstances, and in a sector where, unlike some others, the Chinese government plays a key role not just as director of the economy but as purchaser and regulator, it is possible to conceive of a worst-case scenario in which the significant and profitable presence that the U.S. medical device has established in China could erode or be eliminated.

INTERPRETATION: WHAT DOES IT MEAN FOR THE U.S. ECONOMY?

In a full decoupling scenario, the U.S. would move forward with reshoring supply chains and completely restricting medical device imports from China, while Beijing would retaliate by explicitly prohibiting U.S. firms' participation in public hospital procurement; informally slowing or stopping regulatory approval of U.S. medical devices; and instructing all medical institutions to preference European or Asian medical devices over American ones where domestic substitutes aren't available. Most of the cost associated with this full decoupling scenario would stem from the incremental cost to U.S. businesses and U.S. health consumers of supply chains shifts to countries like Malaysia and Vietnam,[242] and more dramatically the cost of lost U.S. market share in China. Given that U.S. firms currently hold roughly a 30% share of China's total medical devices market, U.S. medical device makers' market share in China

241 Medical Countermeasures include medical devices.

242 Chris Newmarker, "The U.S.-China Trade War: Here's What It Means for Medical Device Industry Suppliers," Medical Design & Outsourcing, July 24, 2019, https://www.medicaldesignandoutsourcing.com/the-u-s-china-trade-war-heres-what-it-means-for-medical-device-industry-suppliers/

could fall from 30% to zero due to decoupling,[243] an annual loss of revenue of $23.6 billion (2018). Not only would U.S. medical device firms lose important revenues, but the lost market share in China would be recouped by U.S. competitors from both China and from other advanced markets, such as the EU and Japan.

But a loss in market share also means missing out on future revenue growth in China's market, where both rising incomes and an aging population are expected to drive demand for medical devices. Assuming that China's medical devices market continues to grow annually by 15% for the next 10 years,[244] the $23.6 billion revenue loss from reduced U.S. market share in 2018 would compound to losses equivalent to $27.14 billion the year after and $31.21 billion in year three, with cumulative lost revenue exceeding $479.17 billion over a decade.[245] Although this decade-long projection necessarily rests on certain assumptions about China's growth and U.S. market share, it contextualizes the magnitude of the opportunity cost if U.S. firms miss out on this vast growth market. Not only would U.S. production and jobs suffer from lost export revenues, but since U.S. medical device makers spend on average 7% of revenue on R&D,[246] an approximately half-trillion dollar loss in revenue would translate into a $33.54 billion reduction in R&D spending over a 10-year period—a drop that could severely compromise U.S. medical device firms' ability to invest in the development of next-generation technologies and products. This would be a particular challenge to U.S. competitiveness, since the revenues forgone in China's huge market would be reallocated to the principal competitors of U.S. device makers in China, Europe, and the rest of Asia, which would enable them to expand their investments. In addition, an exit by U.S. medical device companies from the Chinese market would leave Chinese companies with less competition in a sheltered home market where they would be able to improve their products, grow their revenues, and strengthen their ability to compete with U.S. companies in third markets.

Full decoupling between the U.S. and China has several critical implications for the U.S. medical device industry. First, the opportunity cost of losing access to China's growing health care market would be massive. Not only would U.S. jobs and production dependent on medical device exports to China be jeopardized, but other competitors from Japan, the EU, and China itself would benefit from the revenues that U.S. companies lose. This lost competitiveness would be further exacerbated by a significant reduction in U.S. R&D expenditure. Even if decoupling is limited to tariffs, such costs will reverberate through supply chains as U.S. suppliers are replaced by competitors to different degrees up and down the value chain. These developments would ultimately result in fewer jobs in the U.S. economy and more expensive health care for U.S. consumers.

Additionally, U.S.-China decoupling risks significantly disrupting existing U.S. supply chains in the medical equipment industry. U.S. patients, as well as those around the world, depend on global supply chains to facilitate affordable access to essential medical equipment. These supply chains were built over decades with appropriate safeguards to ensure efficacy, safety, and quality. In particular, U.S. firms rely on supply chain links in China to support U.S. demand that could not be adequately met by relying on exclusively domestic inputs, and for which firms have deemed China to be a more suitable supplier than other third country parties.[247] Amid the unprecedented COVID-19 pandemic, diminished U.S. competitiveness in medical devices development and manufacturing would present not just a significant cost to the U.S. medical device industry, but a cost to human welfare worldwide.

243 The logic behind this calculation is that the U.S. will lose 75% of its hospital sales as China shuts U.S. companies out from hospital procurement, the U.S. it will have 25% of remaining sales left from the private sector. As U.S. holds around 30% of China's total market share in the medical device industry, a simple multiplication of 25% and 30% gives U.S. a 7.5% of market share for U.S. firms in China's medical device industry; Michael Collins, "Protected at Home, China's Medical Device Industry Looks Abroad," Council on Foreign Relations, December 3, 2019, https://www.cfr.org/blog/protected-home-chinas-medical-device-industry-looks-abroad.

244 Yuqi Yang, "The Next Ten Years Will Still Be a Golden Period for the Rapid Development of China's Medical Device Industry," Labmed, October 23, 2019, https://ulabmed.com/content-1431-11646-1.html.

245 The base value here is $23.6 billion and a 15% increase in loss revenue will result in a revenue loss of $27.14 billion the next year. Formula: $23.6x(1.15)=$27.14b. Total aggregation of loss revenue from Year 1 to Year 10 is: $479.17 billion.

246 SelectUSA, "Medical Technology Spotlight," accessed June 2020. https://www.selectusa.gov/medical-technology-industry-united-states

247 SelectUSA, "Medical Technology Spotlight," accessed June 2020. https://www.selectusa.gov/medical-technology-industry-united-states

CONCLUSIONS

After four decades of economic engagement between the U.S. and China, linkages involving trillions of dollars in wealth, assets, and commercial flows have been built up. All are now at risk as political momentum builds toward a future in which the two countries are less engaged. Barring a shift in Beijing's trajectory, which seems unlikely, one must assume that the pressure to disengage, driven by concerns about national security and competitiveness, will remain. It seems clear that there will be differences in how the Biden administration tackles the challenges posed by China compared with the approach of the Trump administration. But one cannot expect a return to engagement as we knew it. Decoupling is likely to continue in one form or another, even if it does evolve in a more measured, targeted way.

China's leadership is focusing attention on economic self-sufficiency, and there are few signs that it is prepared to address Western complaints about distortions arising from the state's role in the economy or to reduce its application of economic statecraft and coercion abroad. In the words of President Xi, China seeks to tighten the dependence of international industrial chains on its economy to form a "powerful retaliatory and deterrent capability."[248] Though CCP leaders continue to promote a message of broader and deeper opening up—which will benefit select foreign industries, such as financial services and insurance—Beijing's overall policy agenda is clearly oriented toward increasing China's own indigenous technological power and economic self-sufficiency. In this regard, the CCP's new "Dual Circulation" strategy has a heavy emphasis on building resilience in domestic supply chains, including an explicit call by Xi himself for import substitution. At the sectoral level, industrial policies clearly state China's goal to surpass America and achieve technological supremacy across a range of advanced industries. The regulatory system offers a suite of tools to serve these goals, including administrative measures, procurement policies, and tightening cybersecurity and data regimes—all of which establish clear preferences for domestic companies over foreign competitors. China is also moving rapidly to build out its corporate "social credit system," which will be used to advance CCP regulatory priorities—such as industrial policy goals—and could become an additional tool to discriminate in favor of domestic companies over their foreign-invested counterparts. Furthermore, as PRC laws have adopted extraterritoriality provisions at an accelerating rate,[249] economic coercion in the form of import bans and content censorship has become a routine response to countries and companies whose political behavior Beijing does not approve of. These trends appear set to continue and will likely empower calls for further decoupling from Washington.

The Biden administration's first priority will likely be shoring up the home front by containing the COVID-19 outbreak and supporting the U.S.' post-pandemic recovery. But China will continue to loom large as the U.S.' top foreign policy challenge—one that goes beyond traditional security threats to include complex policy questions around technology, climate, and critical infrastructure. There is bipartisan agreement on the need to compete with China in a more concerted, strategic way.

The resultant approach will likely include some combination of the following:

- A review of trade and technology policies among like-minded market economies in order to better coordinate responses to China
- A proactive "run faster" agenda that promotes innovation and the competitiveness of U.S. industry
- Urgent action to ensure the resilience of critically important U.S. supply chains
- A rationalization of defensive measures to protect U.S. technology, markets, and other assets from foreign threats

248 Xinhua, "(Shouquan Fabu) Xi Jinping: Zai Jingji Shehui Lingyu Zhuanjia Zuotanhui Shang de Jianghua" [(Official Release) Xi Jinping: Remarks at the Symposium of Experts in Economic and Social Fields], August 24, 2020.
http://www.xinhuanet.com/politics/leaders/2020-08/24/c_1126407772.htm

249 In 2020 alone, China embedded extraterritoriality clauses in the Draft Data Security Law, Draft Biosecurity Law, Export Control Law, and Hong Kong National Security Law.

For policymakers, it will be crucial to consider the cost implications of each of these elements when putting together a strategy. Only by understanding these costs will lawmakers be able to chart an optimal course that addresses national security concerns while ensuring that U.S. companies, workers, innovators, and consumers thrive—both in absolute terms and relative to the competition.

Putting the Pieces Together

Many of the insights from this study come from combining the aggregate and industry pictures.

First and most importantly, although the two levels of data are not directly comparable, the picture of decoupling's potential impact on specific industries is more concerning than impacts at the aggregate level. Macro models suggest that the national economy would absorb losses in some sectors and adjust to new realities in other areas, making decoupling costs look more modest. The industry-level perspective presents a less sanded-down picture of costs to the U.S. manufacturing base, with reductions in market growth outlook, capacity expansion, hiring plans, research budgets, and long-term competitiveness.

Second, decoupling will affect economic relations not only between the U.S. and China, but also between the U.S. and partners in third countries. In our industry analysis, we found that aviation, semiconductors, chemicals, and medical devices all face heavy secondary impacts in third countries, and these impacts will deepen costs and competitiveness challenges.

Third, all U.S. industries with engagement in China are likely to encounter difficulties under a U.S.-China decoupling scenario. Considering how extensive value chain links with China are for automobiles, pharmaceuticals, electronics, telecommunications, apparel, white goods, construction materials, and many other segments, the costs are likely to be substantial. Industries with a technology footprint in China are at particular risk of disruption. Industries with future expectations about growth contingent upon greater participation in China's economy—including hospitality, entertainment, health care, and food and beverage services—also face opportunity costs from decoupling. Disruption caused by decoupling will make it more difficult for firms to maintain their comparative advantage in the marketplace—not just in the U.S. and China, but worldwide.

Beyond the Numbers: Intangibles

Much of the impact from decoupling or the threat of decoupling is too intangible to quantify. Valuing national security gains arising from restrictive engagement is difficult. The task of peacetime economic policymaking is to make propitious choices that lead to prosperity that can function as an incentive to cooperate, a deterrent against rivals, and a wellspring of innovation and security. In this respect, while the best balance between the economic costs of decoupling and the benefits to national security is beyond the scope of economics alone to determine, economics can bring policymakers closer to understanding the costs and trade-offs between different policy options, which will allow us to engage in a better-informed debate about the public interest and preferences.

One particularly important intangible concern facing companies is the loss of their reputation as a reliable partner. This will likely leave U.S. companies with higher borrowing and insurance costs and the need to discount prices to offset customer misgivings. To credibly project the ability to decouple U.S. technology from Chinese use, such as the export of specialized computer chips to Huawei, Washington has demonstrated the ability and willingness to threaten commerce with third countries as well. In this regard, reliable supplier anxieties about U.S. partners are not just a concern limited to doing business in China, but extend to U.S. business relationships around the world.

Recommendations for U.S. Policymakers

Based on this analysis we offer five recommendations for U.S. policymakers.

First, data analysis is critical to policymaking. International relations require a more systemic evaluation of evidence. China policy requires economic impact assessments, cost-benefit analyses, and a process of public debate and discovery. Policy that proceeds from fact-based analysis has a greater likelihood of success and reduces unnecessary costs.

Second, even based on our rough assessment, we can see that the costs of anything approaching "full" decoupling are uncomfortably high. Alternative approaches—including mitigation and in many cases forbearance—would complement any decoupling scenario. A rational approach would be partial (tolerant of goods and services that have no bearing on national security or economic resilience), provisional (adjustable in response to future Chinese changes), and peaceful (stated without malice, to avoid gratuitous, costly escalation).

Third, many elements merit inclusion in a comprehensive U.S. China policy program. They include promoting industry, innovation, and technology; preserving the rules-based, open market order and its institutions; and protecting systemically and strategically important assets and industries from threats, intended and incidental. But success cannot mean that Washington or other market economies offset all the costs of decoupling or prevent painful structural adjustments. In fact, this pain and adjustment is not a side effect of our competitiveness, but the wellspring of it. In the policy reengineering to come, the central role of market forces in determining winners, and the finite capacity of governments to redistribute resources to ease the process, must be respected.

Fourth, policymakers should do their utmost to avoid unilateral catch-all policies that create cost and uncertainty within the U.S. and among like-minded foreign partners. Alignment between national security architects, U.S. business leaders, and leaders of other open-market economies is far preferable to unilateral action. Calls by the Trump administration for new thinking on China resonated with allies and with U.S. business, but attempts to compel alignment through threats should be a last resort and reserved for the most serious threats to national security. Sustainable alignment can only be rooted in a common sense of purpose and shared economic interests and values, and should be based on transparency and institutions.

Finally, policymakers need a clearer timeline for adjustments to the U.S.-China relationship. Trying to decouple this extensive relationship overnight would lead to counterproductive economic hardship. The U.S. and China share a combined $737 billion in two-way trade (in 2018) and more than 100,000 discrete cross-border investment transactions built up over decades. Vast amounts of IP are at work in these transactions and indirectly in commercial arrangements flowing through third-party locations from Ireland to Hong Kong to Bermuda. U.S. policymakers should take the time necessary to collect data, set priorities in light of that data, consult with industry as needed, and draw together like-minded policymakers from other nations to address shared concerns about the choices Beijing has made in recent years.

APPENDIX 1: OVERVIEW OF U.S. DECOUPLING POLICY TOOLBOX

I. Trade: Exchange of Goods and Services		
Category	**Tool**	**Status**
Tariffs: Imposing customs duties on imports from foreign economies	[Enacted] **Section 301 Tariffs** The U.S. initiated a Section 301 trade investigation in March 2018, kicking off a trade war covering more than two-thirds of the value of bilateral trade.	• The U.S. unilaterally imposed several rounds of tariffs on Chinese goods in 2018 and 2019, bringing the average U.S. tariff rate on Chinese imports to 20.9% as of early December 2019. • By the end of 2019, China had responded with tariffs on 100% of the value of U.S. imports to China in most product categories. • After two years of tense negotiations, the U.S.-China Economic and Trade Agreement was signed on January 15, 2020. In signing the deal, both sides agreed to roll back a limited amount of tariffs. • The U.S. continues to maintain tariffs on approximately $360 billion worth of imports from China to serve as leverage for further negotiations on outstanding structural trade barriers.
	[Enacted] **Section 232 Tariffs** In June 2018, the U.S. imposed tariffs on steel and aluminum imports from a wide range of countries, including China.	• Tariffs on steel and aluminum imports from China were kept in place following the signing of the U.S.-China Economic and Trade Agreement.
Export Controls: Restricting and prohibiting the exports of sensitive goods, services, and technical knowledge to foreign end-use/users	[Enacted] **Export Control Reform Act (ECRA)** To broaden export restrictions on dual-use technologies, Congress in August 2018 tasked the DOC with identifying and controlling “emerging and foundational technologies.”	• In November 2018, the DOC’s Bureau of Industry and Security (BIS) listed 14 broad “emerging technology” sectors under consideration for further export controls, including biotechnology, artificial intelligence, and data analytics technology. • In January 2020, the DOC released its first list of emerging technologies. • In August 2020, the DOC began eliciting public comment on foundational technologies.
	[Enacted] **Department of Commerce Entity List** In October 2018, the DOC began adding Chinese companies to the BIS Entity List, subjecting them to specific export license requirements.	• In October 2018, the DOC added telecoms firm ZTE and memory chip maker Fujian Jinhua to the list. • In May 2019, telecoms equipment firm Huawei was added to the list. • In June 2019, Chinese parties developing exascale computing technologies with potential military applications were added to the list. • In October 2019, the DOC added 28 Chinese governmental and commercial organizations complicit in human rights violations in Xinjiang to the list, including several high-tech companies that produce surveillance applications. • In June 2020, the DOC added telecoms provider FiberHome to the list, followed by the addition of two subsidiaries of genomics company BGI in July 2020. • In August 2020, 24 companies were added over South China Sea-related activity. • In December 2020, 60 new entities were added, including chip manufacturer SMIC and drone manufacturer DJI. • In January 2021, the DOC added Chinese oil giant China National Offshore Oil Corporation (CNOOC).

Category	Tool	Status
Export Controls: Restricting and prohibiting the exports of sensitive goods, services, and technical knowledge to foreign end-use/users (continued)	[Enacted] **Export Controls on Military End-Use/Users** In April 2020, the DOC broadened the definition of military end-use and expanded the set of technologies subject to controls.	• In April 2020, new rules were released that tightened export controls related to China. They expanded Military End-Use/User (MEU) controls to cover all military end users in China, as well as specific types of technology. • In December 2020, the DOC released an illustrative list of 58 companies subject to the MEU rules. • The rule also made clear that companies on the DOD Section 1237 list would trigger a "flag" under the MEU rules. • In January 2021, the DOC added Chinese aviation company Skyrizon to the MEU list.
	[Enacted] **Fiscal Year (FY) 1999 NDAA Section 1237** The FY 1999 NDAA required the DOD to identify "Communist Chinese military companies" (CCMCs) operating in the U.S. but was never invoked until 2020. While not an export control itself, the DOD's Section 1237 list authorizes the President to impose sanctions on these firms.	• The DOD issued its first Section 1237 list of companies in June 2020. • The DOD augmented the initial list of companies in August and December 2020 and could possibly make further additions. • The Treasury Department issued guidance in December 2020 and January 2021 to implement former President Trump's November 12, 2020 EO prohibiting U.S. investment in publicly traded securities of Section 1237-listed companies. The guidance confirmed a prohibition on purchasing publicly traded shares in listed companies (most notably China's three telecom giants) beginning January 11, 2021, and OFAC-identified subsidiaries by January 28, 2021. • On January 11, 2021, major Wall Street investors halted purchases of shares in 1237-listed companies, and global index providers cut China's three telecom giants from their benchmarks. • On January 14, 2021, the DOD added 9 PRC companies to the 1237 list, including mobile phone producer Xiaomi and state-owned commercial aircraft giant Commercial Aircraft Corporation of China (COMAC). • On January 15, 2021, the State Department issued a fact sheet listing over 1,100 subsidiaries of 44 CCMCs. • Absent either a successful legal challenge to the November 12 EO or the revocation of the order by President Biden, U.S. investors will be permitted to sell their holdings in 1237-listed companies for the purpose of divestment until to November 12, 2021 (see more on November 12 EO below).
Other Customs Restrictions:	[Enacted] **Withhold Release Orders** In response to human rights violations in China's Xinjiang region, in 2020 and 2021 U.S. Customs and Border Protection (CBP) enacted withhold release orders (WRO) on a variety of goods from Xinjiang.	• In September 2020, CBP restricted imports of some cotton, apparel, hair products, and other goods from Xinjiang. • In December 2020, CBP issued a WRO on all cotton and cotton products from the Xinjiang Production and Construction Corps (XPCC), the largest cotton producer in Xinjiang. • In January 2021, CBP issued a WRO on all cotton and tomato products from Xinjiang, scoped to include products manufactured in third-party countries that contain cotton and tomatoes from Xinjiang.
Industrial Policies: Altering the free-market structure of domestic industries to foster national priorities or interests, including national security	[Enacted] **Executive Order on PRC Software Companies**	• In January 2021, former President Trump issued an EO banning transactions with 8 Chinese software companies and mobile app functions, including Alipay (a standalone e-payment app) and WeChat Pay (an e-payment function of the WeChat app).
	[Enacted] **Executive Orders on TikTok and WeChat**	• In August 2020, former President Trump issued EOs banning transactions with WeChat and TikTok on national security grounds. The EOs face legal challenges and have therefore yet to be implemented.

Category	Tool	Status
Industrial Policies: Altering the free-market structure of domestic industries to foster national priorities or interests, including national security (continued)	[Enacted] **FY 2019 NDAA Section 9904**	• Containing provisions first included in the American Foundries Act introduced in July 2020, FY 2021 NDAA Section 9904 requires the DOC to produce a report on the U.S. microelectronics technology base, which could lead to increased funding for U.S. companies to address identified vulnerabilities in the future.
	[Proposed] **CHIPS for America Act** The bill, first introduced in June 2020, would provide about $23 billion in aid for U.S. semiconductor manufacturers.	• Remains under consideration.
	[Proposed] **America LEADS Act** The bill, first introduced in September 2020, would provide $16 billion in aid for U. S. semiconductor manufacturers and require the President to develop a plan to increase domestic production and mandate domestic sourcing.	• Remains under consideration
Supply Chain Security Rules: Regulating the use of foreign inputs in goods or services consumed in the domestic economy and used by the U.S. government and military	[Enacted] **FY 2019 NDAA Section 889**	• Amends the Federal Acquisition Regulations to prohibit federal government agencies from purchasing certain telecom equipment and services produced by the following five Chinese companies, their subsidiaries, and affiliates: (1) Huawei; (2) ZTE; (3) Hytera; (4) Hikvision; and (5) Dahua. • The DOD will enjoy the authority to add additional companies to the list.
	[Enacted] **FY 2021 NDAA Section 837**	• Requires the DOD to establish a list of critical national security technologies in order to identify pressing national security vulnerabilities.
	[Enacted] **FY 2021 NDAA Section 841**	• Prohibits the DOD from acquiring printed circuit boards from China beginning in 2023.
	[Enacted] **FY 2021 NDAA Section 9905**	• Establishes a multilateral semiconductor security fund and an annual reporting requirement on supply chain security vulnerabilities in the semiconductor industry.
	[Enacted] **Secure and Trusted Communications Act** The bill, first introduced in November 2019, seeks to protect U.S. telecom networks from threats posed by untrusted foreign suppliers.	• The U.S. Federal Communications Commission (FCC) voted in November 2019 to bar use of universal service funding for Huawei and ZTE equipment, effectively barring rural U.S. network providers from continuing to use such equipment. • In February 2020, Congress authorized $1 billion to fund small and rural telecoms providers to rip and replace Huawei and ZTE gear, primarily with equipment from Ericsson and Nokia. In December 2020, the FCC ordered certain telecoms carriers to begin removing the equipment.

Category	Tool	Status
Supply Chain Security Rules: Regulating the use of foreign inputs in goods or services consumed in the domestic economy and used by the U.S. government and military (continued)	[Enacted] **EO on Securing the ICTS Supply Chain**	• In May 2019, former President Trump issued an EO granting the Secretary of Commerce the authority to prohibit U.S. firms from purchasing ICT goods and services supplied by a foreign adversary that pose a national security risk. • In January 2021, the Commerce Department issued an Interim Final Rule to implement the ICTS Supply Chain EO, which designates China as a "foreign adversary" and enables the Commerce Department to enact regulations to create processes and procedures to be used by the Secretary of Commerce to "identify, assess, and address" certain transactions.
	[Enacted] **EO on "Team Telecom"**	• Following the issuance of this EO in April 2020, the White House formalized an interagency group tasked with reviewing and issuing licenses for foreign participation in the telecoms services sector. • In October 2020, the FCC formalized the "Team Telecom" foreign investment review process. • In June 2020, the FCC designated Huawei and ZTE as national security threats; Huawei's designation was upheld In December 2020 following a challenge from the company. • In December 2020, the FCC began the formal process to revoke China Telecom's authorization to operate in the U.S. Similar revocations for China Unicom Americas, Pacific Networks Corp, and ComNet (USA) LLC are under consideration.
	[Enacted] **EO on Taking Additional Steps to Address the National Emergency with Respect to Significant Malicious Cyber-Enabled Activities**	• In January 2021, former President Trump issued an EO to address the use of "Infrastructure as a Service (IaaS)" products—cloud services in particular—by foreign malicious cyber actors to compromise U.S. intellectual property, sensitive data, and critical infrastructure. The EO directs the Secretary of Commerce to propose regulations requiring U.S. IaaS providers to verify the identity of foreign persons obtaining IaaS accounts.
II. Investment: FDI and Portfolio Investment		
Category	**Tool**	**Status**
Investment Screening: Blocking inbound direct and other investments deemed harmful to national interests	[Enacted] **Foreign Investment Risk Review Modernization Act (FIRRMA)** In August 2018, Congress expanded the scope of the investment review mechanism under the Committee on Foreign Investment in the United States (CFIUS), which has the power to block and unwind deals deemed harmful to national security.	• FIRRMA widened CFIUS's power to review deals involving noncontrolling stakes or where high technology is involved without a direct national security threat. • CFIUS has expanded the scope of mandatory disclosures, rejected more investments into the U.S., and unwound a few completed deals.
Financial Sanctions: Limiting the flow of funds to foreign entities in pursuit of economic, foreign policy, or other goals	[Enacted] **EO on Addressing the Threat from Securities Investments that Finance Communist Chinese Military Companies**	• In November 2020, former President Trump issued an EO that bars U.S. investment in publicly traded securities of Communist Chinese military companies, including all Section 1237 companies, effective January 11, 2021. The EO also states that "purchases for value or sales" to divest from listed companies will be permitted up to 11:59pm EST on November 11, 2021. • In December 2020, the Treasury Department clarified that the EO prohibits investment in CCMCs and their subsidiaries, including via exchange-traded funds and index funds. • In January 2021, the President issued a new EO to close perceived loopholes in the original November 2020 EO.

Category	Tool	Status
Financial Sanctions: Limiting the flow of funds to foreign entities in pursuit of economic, foreign policy, or other goals (continued)	[Enacted] **Informal Pressure to Limit Federal Pension Investment** In late 2019, the Trump administration was reportedly weighing policies to curb U.S. portfolio investment flows into Chinese firms.	• In May 2020, the Trump administration successfully pressured the Federal Retirement Thrift Investment Board, which manages federal workers' retirement funds, to halt plans to invest in Chinese equities. The administration is similarly pressuring other federal and state pension funds to limit their China exposure.
	[Enacted] **Holding Foreign Companies Accountable Act** The Holding Foreign Companies Accountable Act will prohibit a company from being listed on a U.S. securities exchange if the company fails to comply with Public Company Accounting Oversight Board (PCAOB) auditing standards within 3 years. It will also require disclosure of government ownership and details on board members' affiliation with the CCP.	• Became law in December 2020.
	[Enacted] **EO on Hong Kong Normalization** An EO introduced by former President Trump in July 2020 determining that Hong Kong was no longer sufficiently autonomous to justify differential treatment from China under U.S. law.	• In December 2020, OFAC sanctioned 14 National People's Congress Standing Committee vice ministers responsible for authorizing Hong Kong's legislature to disqualify pro-democracy lawmakers; more officials are expected to be sanctioned. • In January 2021, OFAC sanctioned 6 Chinese and Hong Kong officials responsible for developing, implementing, and making arrests under Hong Kong's new National Security Law.
	[Enacted] **Hong Kong Autonomy Act** The Hong Kong Autonomy Act requires sanctions to be imposed on individuals and entities involved in implementing the Hong Kong National Security Law. The sanctions extend to financial institutions that hold accounts for these individuals, with banks serving sanctioned officials risking fines or even exclusion from the U.S. financial system.	• Became law in July 2020. • In December 2020, the Treasury Department reported to Congress that it had not found any foreign financial institutions that knowingly conducted a significant transaction with a sanctioned individual.
	[Proposed] **Stop Funding the PLA Act** Introduced in June 2020, this legislation would require U.S. investors to divest from firms with links to the Chinese military.	• Remains under consideration.

Category	Tool	Status
Financial Sanctions: Limiting the flow of funds to foreign entities in pursuit of economic, foreign policy, or other goals (continued)	[Proposed] **Presidential Working Group on Financial Markets** The Presidential Working Group on Financial Markets, established in June 2020, has proposed rules to prevent listings or to delist Chinese companies that fail to provide auditing documents.	• In November 2020, the U.S. Securities and Exchange Commission (SEC) issued guidance illustrating the risks associated with investments in China-backed issuers and detailed the U.S.' limited ability to inspect Chinese auditing work and conduct regulatory oversight. • The Working Group's proposed measures have prompted many Chinese companies to rethink their location for an initial public offering (IPO), now favoring Hong Kong or Mainland China over the U.S. To avoid being potentially forced to delist, some Chinese companies have also voluntarily delisted in the U.S., or are considering delisting.
	[Proposed] **Removal of MOU** In July 2020, the White House proposed plans to eliminate a memorandum of understanding between U.S. and Chinese securities regulators that sought to allow the freer exchange of auditing documents.	• Remains under consideration.
III. People and Ideas: R&D, Tourism, and Education		
Category	**Tool**	**Status**
Indictment and Sanctions: Punishing or sanctioning individuals for their alleged misconduct	[Enacted] **The Department of Justice's China Initiative** The initiative, established in November 2019, aims to identify and prosecute Chinese individuals engaging in trade secret theft, hacking, and economic espionage.	• The DOJ has charged, convicted, and sentenced dozens of individuals and companies for various corporate espionage activities under the program in recent years. • The arrest in December 2018 of Huawei CFO Meng Wanzhou in Canada on U.S. charges, and the subsequent detention of two Canadian nationals in China, has increased unease among business travelers in both countries. • In December 2020, a Chinese national working at the U.S. videoconferencing company Zoom was arrested in relation to a scheme to disrupt virtual meetings in commemoration of the June 4, 1989 Tiananmen Square massacre.
	[Enacted] **EO on Hong Kong Normalization**	• In June 2020, the State Department announced visa restrictions on current and former CCP officials complicit in undermining Hong Kong's autonomy and human rights. • The U.S. expanded the visa restrictions in December 2020 to include 14 vice ministers on the National People's Congress Standing Committee.
	[Enacted] **Hong Kong Autonomy Act**	• In August 2020, OFAC added Hong Kong Chief Executive Carrie Lam and 10 other Hong Kong and PRC officials to the SDN List.
	[Enacted] **Global Magnitsky Human Rights Act Sanctions**	• In July 2020, OFAC announced sanctions under the Global Magnitsky Act on Xinjiang's party secretary (a Politburo member) and three associated officials, the first time that the U.S. had sanctioned high-level Chinese officials.

Category	Tool	Status
Travel Restrictions: Limiting people flows through suspension or cancellation of visas	[Enacted] **Presidential Proclamation on Chinese Students and Researchers** A proclamation by former President Trump in May 2020 accused China of engaging in a "wide-ranging and heavily resourced campaign to acquire sensitive United States technologies and intellectual property."	• Following the proclamation, the U.S. revoked the visas of more than 1,000 Chinese students and researchers deemed to be security risks. • The U.S. intelligence community and law enforcement agencies are actively raising awareness among U.S. research institutions about the risks of collaborating in certain fields with Chinese researchers and scholars who receive funds from Chinese companies or the Chinese government.
	[Enacted] **Visa Suspensions for Highly-Skilled Workers**	• In June 2020, the U.S. temporarily suspended the issuance of new H-1B visas for specialized roles, such as professors, researchers, and computer programmers. • In October 2020, the Trump administration announced new rules to further tighten eligibility for the H-1B visa program.
	[Enacted] **Visa Restrictions on United Front Work Department Officials**	• In December 2020, the State Department announced visa restrictions on officials linked to Chinese overseas influence operations and individuals participating in United Front Work Department-affiliated campaigns.
	[Enacted] **Visa Limitations on CCP Members**	• In December 2020, the State Department reduced travel visas for members of the CCP and their immediate family from 10 years to 1 month and restricted them to single-entry.
	[Enacted] **Visa Limitations on Chinese Journalists in the U.S.**	• In March 2020, the State Department limited to 100 the number of Chinese citizens working in the U.S. for five state-owned media outlets. • In May 2020, the Department of Homeland Security (DHS) limited visas for Chinese journalists working at non-U.S. outlets in the U.S. to 90-day visas. These changes mirror Beijing's expulsion of foreign journalists from China earlier in 2020.
	[Proposed] **SECURE CAMPUS Act** This bill, first introduced in June 2020, would prohibit Chinese nationals from studying science, engineering, technology, or mathematics in the U.S.	• Remains under consideration.
Termination of Exchange Programs: Cancelling people-to-people and intergovernmental exchanges	[Enacted] **Termination of U.S.-PRC Cultural Exchanges**	• In December 2020, the State Department determined the following five programs were funded and operated by China as soft power propaganda tools and announced their termination: the Policymakers Education China Trip Program, U.S.-China Friendship Program, U.S.-China Leadership Exchange Program, U.S.-China Transpacific Exchange Program, and Hong Kong Educational and Cultural Program.

Sources: U.S. Chamber of Commerce, Rhodium Group. Updated as of January 21, 2021.

APPENDIX 2: OVERVIEW OF U.S. DECOUPLING LITERATURE

Publication Date	Author(s)	Title	Publication	Key Findings/Arguments
October 21, 2019	Steven Byers and Jeff Ferry	Decoupling from China: An Economic Analysis of the Impact on the U.S. Economy of a Permanent Tariff on Chinese Imports (Link)	*Business Economics*	Permanent 25% across-the-board tariffs on imports from China would lead to significant gains in GDP and employment and a large reorientation of U.S. supply chains.
May 7, 2020	John Lee	Decoupling the US Economy from China after COVID-19 (Link)	Hudson Institute	The U.S. government will seek to capture more of the value in global production processes at home, and the U.S. should increasingly develop approaches to deny or restrict Chinese firms' access to capital, markets, and know-how in the MIC sectors.
June 2020	Peter Petri and Michael Plummer	East Asia Decouples from the United States: Trade War, COVID-19, and East Asia's New Trade Blocs (Link)	Peterson Institute for International Economics	Regional trade agreements in Asia (RCEP, CPTPP) will yield benefits for China, Japan, and South Korea, and losses for the U.S. and India.
June 3, 2020	Minghao Li, Edward J. Balistreri, and Wendong Zhang	The U.S.–China Trade War: Tariff Data and General Equilibrium Analysis (Link)	*Journal of Asian Economics*	The remaining tariff increases as of March 2020 after the Phase One trade deal decrease welfare in China by 1.7% and welfare in the U.S. by 0.2%; China's exports to and imports from the U.S. are reduced by 52.3% and 49.3%; and trade flow between the U.S. and China will be diverted to their major trade partners, resulting in higher welfare in those countries, including many Asian nations.
September 2020	Elisabetta Gentile, Gen Li, and Mahinthan Joseph Mariasingham	Assessing the Impact of the United States–People's Republic of China Trade Dispute Using a Multiregional Computable General Equilibrium Model (Link)	Asia Development Bank	The bilateral measures implemented as of May 2019 would result in GDP contraction with respect to the baseline by 0.17% in the U.S. and 0.36% in China, employment contraction by 0.24% in the U.S. and 0.55% in China, consumption contractions by 0.14% in the U.S. and 0.20% in China, and investment contraction by 0.45% in the U.S. and 0.64% in China. A scenario based on additional 25% tariffs on all bilateral imports would result in an even larger contraction with trade diversion to other Asian economies.
March 19, 2020	Eddy Bekkers and Sofia Schroeter	An Economic Analysis of the US-China Trade Conflict (Link)	World Trade Organization	The trade conflict has resulted in reduced bilateral trade and considerable trade diversion to imports from other regions, leading to a reorganization of value chains in (East) Asia. The direct effects of the tariff increases on the global economy are limited (0.1% reduction in global GDP), with an even smaller impact resulting from the Phase One Agreement. The biggest impact of the trade conflict is the rise in uncertainty about trade policy.

Publication Date	Author(s)	Title	Publication	Key Findings/Arguments
September 2020	Stewart Patterson	US-China Economic Decoupling: How Far Have We Come and How Far Could Decoupling Go (Link)	Hinrich Foundation	Geo-economic confrontation has progressed with a speed that has surprised many, and the economic conflict is broadening in its scope to entail elements of a great power rivalry. This paper explores the likely scope of economic confrontation in trade, FDI, capital markets, and payment systems.
July 2020	Derek Scissors	Partial Decoupling from China: A Brief Guide (Link)	American Enterprise Institute	Decoupling involves a range of tools and economic activities that policymakers should quickly use to respond to Chinese subsidies, implement already legislated export control reform, monitor and possibly regulate outbound investment, and provide legal authority to move or keep supply chains out of China. The costs of decoupling—higher prices, lower returns on investment, and lost sales—are dwarfed by the costs of continued Chinese economic predation and the empowerment of the CCP.
July 2020	Scott Kennedy	Washington's China Policy Has Lost Its Wei (Link)	Center for Strategic and International Studies	The U.S. strategy to crush Huawei and decouple the Western world from China's telecom and semiconductor industries could seriously harm the U.S. economy and national security. The campaign threatens U.S. global leadership and accelerates China's technological independence. A U.S. strategy of "principled interdependence" would address the risks posed by Huawei and China's high-tech drive, while continuing to derive benefit from being part of a dynamic global economy.
August 20, 2020	Torsten Riecke	Resilience and Decoupling in the Era of Great Power Competition (Link)	Mercator Institute	The U.S. and China are using control over important value chains to assert geopolitical interests. Decoupling is particularly evident in the semiconductor industry, where the U.S. has an advantage and is trying to cut off China's global telecoms giant Huawei from the Western technosphere. Continued decoupling could split the global market into competing technospheres.
June 2020	Alex Capri	Strategic US-China Decoupling in the Tech Sector (Link)	Hinrich Foundation	Certain strategic value chains will decouple, restructure, and diversify out of China as reshoring and ring-fencing some critical manufacturing becomes unavoidable. Multinationals will need to adjust to a world of increasingly fragmented and localized value chains and adopt "in-China-for-China" business models if they wish to access the Chinese market.

Source: U.S. Chamber of Commerce.

METHODOLOGY APPENDIX A: AVIATION

Snapshot of Annual Costs

We reference the Federal Aviation Administration's (FAA's) January 2020 report on the economic impact of civil aviation on the U.S. economy for baseline data about how civil aviation manufacturing output is related to jobs, revenue, and value added:

- Federal Aviation Administration, "The Economic Impact of Civil Aviation on the U.S. Economy," January 2020. https://www.faa.gov/about/plans_reports/media/2020_jan_economic_impact_report.pdf

Standard economic studies consider two types of economic impacts: primary and secondary. In aviation, primary impacts are the sum of revenue earned by each industry segment from the sale of goods and services—direct or supply chain spending—relevant to civil aviation. We adopt a baseline calculation of impacts using FAA research, which categorizes airline operations, aircraft manufacturing, other manufacturing, and air couriers as direct sectors within the aviation industry, and categorizes visitor expenditures and travel arrangers as catalytic sectors—those that are related to civil aviation. We focus on manufacturing for this report. Secondary economic impacts are calculated using a "multiplier" derived from FAA data to estimate how aviation incomes support demand in other sectors.

The FAA analysis relies on data from the U.S. Department of Commerce, Department of Transportation, Department of Labor, and National Science Foundation from the years 2014 to 2016. Data on primary economic impacts were gathered from government and private sources. The RIMS II model, developed by the Bureau of Economic Analysis (BEA), references the 2007 U.S. input-output table to derive secondary spending. The input-output framework underlying RIMS II imposes at least six assumptions that need to be considered when conducting an economic impact study: backward linkages; fixed purchase patterns; industry homogeneity; no supply constraints; no regional feedback; and no time dimension.

The 2020 report takes 2016 data as its base, given the time it takes to produce a detailed, integrated production account of U.S. economic activity. The FAA indicated a slight reduction in multipliers from 2014 to 2016, resulting in lower jobs, earnings, and value-added relative to gross output, but for this study we assume the same multipliers hold.

For our calculation, we assume decoupling results in full loss of U.S. aircraft sales to China and related U.S. aircraft manufacturing output. We adjust downward the FAA's primary output figure by Boeing's 2016 China revenue ($10.3 billion). For other aviation industries, we consider the costs of a 10% and 20% reduction in output as a proxy for lost China sales, assuming that 10% to 20% of U.S. global sales are absorbed by China. We base this range on available financial data from a small sample of firms that report China or Asia Pacific revenue. We calculate research and development (R&D)-related losses based on Boeing's R&D spending-to-earnings ratio, and we assume civilian aircraft R&D intensity of 4.9%.

METHODOLOGY:

- Based on the above assumptions, we estimate the change in primary output for civil aviation manufacturing industries. As no market can replace China as a consumer at scale, we assume a reduction in sales is equivalent to a reduction in primary output. In the FAA's model, gross output—or production—is measured as total sales or receipts, plus other operating income, commodity taxes (sales and excise taxes), and changes in inventories.[1]

- Decomposing the FAA's 2020 update to the industry's U.S. economic impact, we extrapolate multipliers that capture the relationship between primary output (treated as equivalent to sales) and total output, earnings, and jobs. We adjust primary output downward based on our above assumptions about decoupling impacts above.

LIMITATIONS:

- Because we derive multipliers for total output, earnings, and jobs based on their relationship to primary output, the estimated impacts from decoupling are reflections of our assumed reduction in primary output in each industry. We did not conduct any new economic or modeling work in this approach.

1 Federal Aviation Administration, "The Economic Impact of Civil Aviation on the U.S. Economy," January 2020, https://www.faa.gov/about/plans_reports/media/2020_jan_economic_impact_report.pdf.

- Our assumptions about how much revenue and output are derived from China activity are extrapolated and based on publicly available information, and so should not be considered authoritative estimations based on actual revenues or shipments.

- We do not adjust prices or dollars. FAA baseline data are reported for 2016. We use 2016 trade and output data where available; if not available, we adjust 2016 data by relevant ratios or percentages (e.g., share of China sales) from recent years.

Extending Forward: How to Think about Longer-Term Costs

We use projections about growth in China's aircraft demand and maintenance, repair, and overhaul (MRO) and other commercial services market to estimate the value of potential lost U.S. market share in those industries under decoupling. We reference two resources:

- Tom Cooper et al., "Global Fleet & MRO Market Forecast Commentary 2019-2029," Oliver Wyman, 2019. https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2019/January/global-fleet-mro-market-forecast-commentary-2019-2029.pdf

- Boeing, "Commercial Market Outlook, 2019-2018," September 2019. http://www.boeing.com/resources/boeingdotcom/commercial/market/commercial-market-outlook/assets/downloads/cmo-sept-2019-report-final.pdf

Taking pre-COVID growth projections for China's fleet and MRO spend growth as a baseline, we calculate the value of the U.S.' loss of market share in China's expanding fleet, and the value of lost U.S. market share in China's MRO market, over a 10-year and 20-year time horizon. We make a number of assumptions to simplify this thought experiment:

- We assume the U.S. China market share for aircraft is 45%, with Europe holding 45% and domestic competitors holding 10%. To simulate decoupling, we calculate the cost of the U.S. market share falling to zero.

- We calculate the potential revenue lost each year based on projected additions to China's fleet (i.e., newly purchased fleet each year).

- We use $160 million as the average price per aircraft to calculate a dollar value of projected new aircraft deliveries each year, based on Boeing's projected China market value for new aircraft.

- We assume U.S. companies hold 33% of China's MRO market. There is no single credible estimate of China's MRO market share held by U.S. firms, as the market is fragmented and evolving, so we draw on the following figures:

    - Foreign companies complete 65% of MRO services in China.[2]

    - Officially, of the 859 MRO firms in China, 467 are Chinese and 392 are foreign, of which U.S. firms number 193.[3]

    - If we assume market share is proportionate to the number of companies active in the market, we can infer that U.S. firms hold 33%. This may undercount non-MRO firms that provide MRO services.

Based on these assumptions and the Oliver Wyman projections, we calculate the value of a constant U.S. market share (45%) of China's marginal aircraft fleet growth and estimated MRO market share of 33% for China's MRO annual spend from 2020 to 2029. Oliver Wyman data provide annual growth rates, allowing a year-by-year breakdown of the value of U.S. market share over the time period.

To get to the longer-term estimate, we use Boeing projections, which extend through 2038 but are less detailed in that they do not report annual figures for growth or market size. We repeat the exercise, calculating the value of U.S. market share in China's aircraft purchase growth and MRO and other commercial services market from 2020 to 2038.

2 Qianzhan Research Institute, "Foreseeing 2019: Complete Roadmap of China's Aviation Industry in 2019," March 2019. https://zhuanlan.zhihu.com/p/59098485.

3 Ibid.

METHODOLOGY APPENDIX B: SEMICONDUCTORS

In quantifying the costs of decoupling to the U.S. industry and economy, we focus on two main scenarios: a reduction in U.S. semiconductor sales to China, simulating export controls, and bilateral tariffs.

Our estimations provide only a broad picture of the costs of decoupling. We discuss the impacts of the two developments separately, because the relevant studies look at different indicators, timelines, and baselines. Therefore, these estimates should not be considered exhaustive or mutually exclusive. Our approach takes assumptions about the impacts of loss of U.S. sales to China produced by the Boston Consulting Group (BCG) as a baseline decoupling scenario, and extends the BCG report findings to look at additional estimated costs.

Our key estimates come from the following studies:

- Antonio Varas and Raj Varadarajan, "How Restricting Trade with China Could End U.S. Semiconductor Leadership," Boston Consulting Group, March 9, 2020.
  https://www.bcg.com/publications/2020/restricting-trade-with-china-could-end-united-states-semiconductor-leadership.aspx

- Daniel H. Rosen, Lauren Gloudeman, and Badri Narayanan Gopalakrishnan, "Assessing the Costs of Tariffs on the U.S. ICT Industry: Modeling U.S. China Tariffs," U.S. Chamber of Commerce, March 15, 2019.
  https://rhg.com/research/assessing-the-costs-of-tariffs-on-the-us-ict-industry/

Lost China Sales

The Boston Consulting Group Report (BCG) estimates the loss of U.S. semiconductor sales revenue and impacts on global market share, revenue, and other variables.

To estimate how decoupling would affect U.S. company sales in China, BCG uses six different modules. The first three break down sources of demand and supply within the global semiconductor market by end device category, semiconductor product category, and region. Another module models how end users of semiconductor-incorporated devices would change their behavior in response to restrictive policies. The next module models three semiconductor supplier substitution dynamics: Made in China 2025, the forced substitution of U.S. suppliers, and the proactive substitution of U.S. suppliers. The final module calculates how changes in revenues correspond to changes in semiconductor firms' spending. The data underlying these modules are primarily from Gartner and World Semiconductor Trade Statistics, and the Semiconductor Industry Association's annual reports.

BCG's base case is that the U.S. will lose 50% of its China revenue within a two- to three-year time frame, while its "full decoupling" scenario assumes an immediate 100% drop in China revenue.

Production and Compensation

To estimate the effect of the loss of China revenue on U.S. production and employee compensation, we build on BCG's base case scenario that there will be a 50%, or $36 billion, loss of revenue. Because BCG estimates are based on 2018 figures, the estimates we derive are also based in 2018.

We assume that a $36 billion loss of sales is the same as a $36 billion drop in final demand for semiconductor and related device manufacturing (NAICS code 334413). Final demand represents demand from an end user of a product, as opposed to intermediate demand. In input-output tables, exports are considered a source of final demand. In this exercise we assume that exports are equivalent to sales, though sales also reflect intra-firm sales, transportation costs, and intangible value that may not be included in export data.

We plug the assumed $36 billion drop in final demand into the 2012 total requirement table provided by the BEA. The table shows the production required, both directly and indirectly, to deliver $1 of a product for final use, and it provides a breakdown of contribution by commodity and industry. Every $1 of demand for semiconductor manufacturing implicates $1.5 worth of production. Thus, a $36 billion drop would implicate $54 billion in total output. This estimate assumes that the ratio of semiconductor manufacturing production and the production of other goods has not changed since 2012.

To approximate the effect this would have on compensation, we multiply the change in production for each industry by the ratio of production to employee compensation from a 2012 BEA input-output table. $54 billion implicates $20.1 billion in total compensation. This estimate assumes that both the total requirement ratios for semiconductors and the output to compensation ratios of industries have stayed the same since 2012.

METHODOLOGY APPENDIX C: CHEMICALS

Based on our industry stakeholder interviews, the biggest U.S.-China decoupling impacts would arise from trade disruption. Chinese tariffs would reduce demand for chemicals from the U.S. by pushing up prices, though how much depends on how "elastic" China's demand is or whether substitutes are available. In October 2018 the American Chemistry Council (ACC) published a study estimating the impact of retaliatory tariffs from China:

- American Chemistry Council, "An Assessment of the Impact of Retaliatory Tariffs on U.S. Chemical Exports to China: Jobs Lost and Economic Harm," October 2018.
  https://www.americanchemistry.com/Policy/Trade/An-Assessment-of-the-Impact-of-Retaliatory-Tariffs-on-U.S.-Chemical-Exports-to-China.pdf

Our approach to calculating decoupling costs, interpreted as retaliatory Chinese tariffs on imports from the U.S., takes the ACC study as the baseline for the hit to the industry and economy under the first three rounds of bilateral tariffs implemented in 2018. The ACC study results are summarized in Table C-1.

Table C-1: Economic Impact on U.S. Chemicals Industry and U.S. Economy from Export Demand Loss in China Due to Section 301 Tariffs Levied in 2018

Tariffs cover approximately $110 billion in U.S. exports to China (2017)

	Jobs at Risk		Lost Payroll (USD billion)		Lost Output (USD billion)	
Impact Type	**Relatively Inelastic Response, Near Term**	**Relatively Elastic Response, Longer Term**	**Relatively Inelastic Response, Near Term**	**Relatively Elastic Response, Longer Term**	**Relatively Inelastic Response, Near Term**	**Relatively Elastic Response, Longer Term**
Direct (chemicals and plastics)	2,184	8,243	0.2	0.7	1.6	6.1
Indirect (supply chain)	6,073	22,933	0.5	1.8	2.1	7.8
Payroll-Induced Spending	6,189	23,369	0.3	1.2	1.0	3.8
Total Impact on U.S. Economy	**14,446**	**54,545**	**1.0**	**3.8**	**4.7**	**17.7**

Source: ACC, "An Assessment of the Impact of Retaliatory Tariffs on U.S. Chemical Exports to China: Jobs Lost and Economic Harm," October 2018. Results simulated using an IMPLAN model.

Updating Tariff Coverage

In Table C-2, we show U.S. exports by product segment covered by China's retaliatory tariffs in the first three rounds of tariffs levied in 2018, modeled in the ACC impact study.[4] For comparison with the ACC study, we add plastics and products thereof to chemicals. By our estimation, 31% of the *value* of U.S. chemicals and plastics product exports to China were subject to tariffs at the end of 2018.

Table C-2: U.S. Chemicals Exports to China Subject to China's Tariffs in 2018 (First Three Rounds)
USD billion, 2018 trade values[5]

	Exports to China	Exports to World	China Exports Subject to Tariffs	Share of China Exports Subject to China Tariffs	Share of World Exports Subject to China Tariffs
Inorganic Chemicals, Rare Earths, Radioactive Compounds	1.0	12.5	0.0	2%	0%
Organic Chemicals*	3.9	40.3	3.2	83%	8%
Pharmaceutical Products	3.9	48.3	0.1	3%	0%
Fertilizers	0.0	4.2	0.0	21%	0%
Tanning and Dye, Paint, Putty, Inks	0.5	8.0	0.0	4%	0%
Essential Oils, Perfumes, Cosmetic Preparations	1.3	13.6	0.3	22%	2%
Soaps, Waxes, Polish, Candles	0.9	7.3	0.9	100%	12%
Albuminoidal Substances, Modified Starch, Glue, Enzymes	0.5	3.6	0.4	87%	12%
Explosives, Pyrotechnics	0.0	0.8	0.0	17%	1%
Photographic or Cinematic Goods	0.6	2.2	0.1	21%	5%
Miscellaneous Chemical Products	3.8	30.3	1.1	30%	4%
Plastics and Products	7.1	66.6	1.0	14%	1%
Subtotal: Chemicals	**16.5**	**171.0**	**6.3**	**38%**	**4%**
Subtotal: Chemicals Less Pharmaceuticals	**12.6**	**122.7**	**6.2**	**49%**	**5%**
Total Chemicals and Plastic Products	**23.6**	**237.6**	**7.2**	**31%**	**3%**

Sources: State Council, Census, MOFCOM. U.S. exports to China and U.S. exports subject to Chinese tariffs are based on values reported by China Customs for better comparability; there is a less than 1% difference in China-reported and U.S.-reported values in these commodities. "Chemicals" includes HS chapters 28-38. "Plastics and products" includes HS chapter 39. *We account for China's tariff exemption for organic chemicals imports in September 2018.

4 "Chemicals" includes Harmonized System (HS) chapters 28-38; "plastics and products" thereof includes HS chapter 39.

5 We use 2018 values based on availability of detailed China Customs data, whereas the ACC study uses 2017 data.

Because the U.S. and China use different product classification systems at the tariff line level of granularity, we use China Customs data from 2018 to compare U.S. exports to China and those subject to China's retaliatory tariffs. China's trade data and tariff notices reference 8-digit product codes, whereas U.S. tariff notices apply to 10-digit product codes (less granular versus more granular), likely resulting in overstatement of U.S. exports to China subject to tariffs. However, there is a less than 1% difference in China-reported and U.S.-reported export values in these commodities, indicating they are very consistent.

Extending Economic Impact

In extending the ACC's impact study results, we first look at where China raised additional tariffs in 2019. Because China could not match U.S. tariff escalation with tit-for-tat retaliation, its 2019 tariffs applied higher tariff rates on products already subject to earlier rounds of tariffs in 2018. For that reason, we consider only marginal tariffs—the addition of tariffs on U.S. exports to China that weren't already tariffed.

Our approach determines the share of U.S. chemicals and plastics exports subject to retaliatory Chinese tariffs in all four rounds (through end-2019). We sum these exports for comparison with NAICS classifications. We calculate 2018 output of these two categories by adjusting the BEA 2012 supply table by Federal Reserve-reported industrial production indexes to get to baseline real output values. We then derive the impact of tariffs on 31% of U.S. exports to China by back-calculating the impact on output from BEA data and ACC's reported reduction in output. We assume the percentage increase in tariff coverage results in a commensurate decrease in output, payroll, and jobs under the two scenarios.

LIMITATIONS:

- Because we derive multipliers for total output, payroll, and jobs based on their relationship to chemicals and plastics output, the estimated impacts from decoupling are reflections of our assumed reduction in output in each industry.

- We assume the percentage increase in tariff coverage results in a commensurate decrease in output, payroll, and jobs. As a result of the 79% increase in U.S. export value covered by China's tariffs (from 31% in 2018 to 55% in 2019), we look at the value of 79% reductions in output, payroll, and jobs as costs. We did not conduct any new economic or modeling work in this approach.

- Since the ACC study looks at indirect and catalytic economic impacts, application of our tariff coverage approach to those secondary impacts likely overstates costs and is more relevant for considering impact narrowly in the U.S. chemicals and plastics industries.

METHODOLOGY APPENDIX D: MEDICAL DEVICES

We estimate costs to U.S. industry and the economy from two aspects: (1) lost China sales and (2) tariff-induced costs.

Lost China Sales

We estimate the potential loss in sales for U.S. medical device companies if their market share in China drops to 0% from 30%. Key statistics we referenced include the following:

- **Current U.S. market share of medical devices in China: 30%**
  Michael Collins, "Protected at Home, China's Medical Device Industry Looks Abroad," Council on Foreign Relations, December 3, 2019.
  https://www.cfr.org/blog/protected-home-chinas-medical-device-industry-looks-abroad

- **The market size of China's medical devices sector: $78.8 billion**
  U.S. International Trade Commission, "Healthcare Resource Guide: China," October 2019.
  https://2016.export.gov/industry/health/healthcareresourceguide/eg_main_108574.asp

- **China's medical devices market growth rate of the next decade: 15%**
  Yuqi Yang, "The Next Ten Years Will Still Be a Golden Period for the Rapid Development of China's Medical Device Industry," Labmed, October 23, 2019. https://ulabmed.com/content-1431-11646-1.html

The value of the 30% share of China's $78.8 billion (2018) medical devices market held by U.S. medical device makers is $23.6 billion, which we take as the annual U.S. revenue lost under decoupling. Taking into consideration the growth rate of China's medical devices market, we further extend the one-year lost revenue estimation to a 10-year cost analysis. The base value here is $23.6 billion; thus, a 15% increase in lost revenue will result in an estimated revenue loss of $27.14 billion the following year.

The logic of this calculation is that, if the medical devices market in China grows at a rate of 15% annually, the lost revenue of U.S. medical devices will also increase by 15% each year from the previous year given that the U.S. market share of China's medical device industry is at 0% instead of the supposed 30%.

LIMITATIONS:

The above calculation simplifies many factors from the real world; for example, China's market growth rate in the sector might not consistently grow at 15% in the next decade, and U.S. market share of China's medical device industry might not maintain at 30% constantly.

Costs of Bilateral Tariffs

Assessing the value of U.S. trade subject to Section 301 tariffs is relatively straightforward, as trade data are reported at the 10-digit level with the same classification as tariff reporting.

Because the U.S. and China use different product classification systems at the tariff line level of granularity, we use China Customs data from 2018 to compare U.S. exports to China and those subject to China's retaliatory tariffs. China's trade data and tariff notices reference 8-digit product codes, whereas U.S. tariff notices apply to 10-digit product codes (less granular versus more granular), likely resulting in overstatement of U.S. exports to China subject to tariffs. However, to our knowledge, China Customs data are the most comprehensive available. In total, China-reported U.S. exports in the medical device categories that we consider in this analysis are 18% higher than the U.S. Census Bureau reported, showing the possibility of discrepancies and suggesting China's data do not offer a fully comprehensive and comparable account of the value of its trade subject to retaliatory tariffs. We sum China's 8-digit tariff line trade values covering 43 products based on matching 6-digit codes, which should at minimum aggregate tariff line items into accurate broader categories. The tariffs considered here are effective as of end-2019; since then some exemptions have been granted by both parties.

This analysis is further complicated by overlapping tariffs on China's imports subject to tariffs. While its first three rounds of tariffs applied to individual tariff line items, its fourth round in 2019 covered some products that were already covered in the first three rounds, effectively increasing the tariff rate of those imports. In our calculation, we consider only the value of U.S. exports to China subject to tariffs; we do not double-count exports that are subject to multiple rounds of tariffs.

In aggregating medical devices trade by product segment (as shown in Table D-1), we use classification presented in the following source:

- Mihir P. Torsekar, "China's Changing Medical Device Exports," U.S. International Trade Commission, January 2018.

Table D-1: Medical Devices by Harmonized Tariff Schedule Description and Product Categories

HS Products	Description	Category
3005	Bandages Etc Coated Etc Or In Retail Medic Etc	Disposables
300630	Opacifying Preparations For X-Ray Examinations	Diagnostic
300650	First-Aid Boxes And Kits	Disposables
300640	Dental Cements And Other Dental Fillings Etc	Therapeutic
300691	Appliances Identifiable For Ostomy Use	Therapeutic
3821	Prepared Culture Media For Development Of Microorganisms	Intravenous Devices
3822	Composite Diagnostic/Lab Reagents, Exc Pharmaceut	Intravenous Devices
401519	Gloves, Except Surgical Etc, Vulcan Rubber, Nesoi	Disposables
401511	Surgical & Med Glove, Vulcanize Rubber	Disposables
611510	Graduated Compression Hosiery	Disposables
841920	Medical, Surgical Or Laboratory Sterilizers	Surgical Instruments

(Continued on next page)

HS Products	Description	Category
8713	Carriages For Disabled Persons, Motorized Or Not	Other
871420	Parts & Accsries Of Carriages For Disables Persons	Parts
900140	Spectacle Lenses Of Glass	Surgical Instruments
900130	Contact Lenses	Therapeutic
901890	Instr & Appl F Medical Surgical Dental Vet, Nesoi	Surgical Instruments
901839	Med Needles. Nesoi, Catheters Etc And Parts Etc	Disposables
901831	Syringes, With Or Without Needles; Pts & Access	Surgical Instruments
901812	Ultrasonic Scanning Apparatus	Diagnostic
901819	Electro-Diagnostic Apparatus Nesoi, And Parts Etc.	Diagnostic
901813	Magnetic Resonance Imaging Apparatus	Diagnostic
901849	Inst & Appln For Dental Science, & Pts & Acc, Nesoi	Surgical Instruments
901832	Tubular Metal Needles & Needles For Sutures &Parts	Disposables
901850	Other Ophthalmic Instruments & Appliances & Parts	Surgical Instruments
901811	Electrocardiographs, And Parts And Accessories	Diagnostic
901841	Dental Drill Engines And Parts And Accessories	Therapeutic
901814	Scintigraphic Apparatus	Diagnostic
901820	Ultraviolet Or Infrared Ray Apparatus, & Pts & Acc	Diagnostic
9019	Mech-Ther, Massage, Psych Test, Ozone App Etc, Pts	Therapeutic
902110	Orthopedic Or Fractre Appliances, Parts & Accessor	Therapeutic
902140	Hearing Aids	Therapeutic
902190	Oth Artificial Pts Of The Body & Pts & Accessories	Therapeutic
902121	Artificial Teeth And Parts And Accessories	Therapeutic
902131	Artificial Joints And Parts And Accessories Thereof	Therapeutic
902139	Artificial Joints & Parts & Accessories Thereof, Nes	Therapeutic
902129	Dental Fittings And Parts And Accessories	Therapeutic
902150	Pacemakers For Stimulating Heart Muscles	Therapeutic
902212	Computed Tomography Apparatus	Diagnostic
902214	Appts Base On X-Ray, Medical, Surgical, Vetnry, Nesoi	Diagnostic
902230	X-Ray Tubes	Diagnostic
902221	Appts Base On Alpha, Beta, Etc Radiation, Medical, Etc	Diagnostic
902213	Appts Base On X-Ray For Dental, Uses, Nesoi	Parts

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