ASSESSING THE COSTS OF TARIFFS ON THE U.S. ICT INDUSTRY

MODELING U.S.-CHINA TARIFFS

U.S. CHAMBER OF COMMERCE
International Affairs

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RHODIUM GROUP

U.S. CHAMBER OF COMMERCE

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ACRONYMS AND ABBREVIATIONS

BIS	Bureau of Industry and Security
CFIUS	Committee on Foreign Investment in the United States
CGE	Computable General Equilibrium
ECRA	Export Control Reform Act
FIE	Foreign-Invested Enterprise
FIRRMA	Foreign Investment Risk Review Modernization Act
GSC	Global Supply Chain
GTAP	Global Trade Analysis Project
GVC	Global Value Chain
ICT	Information and Communication Technology
IMF	International Monetary Fund
IP	Intellectual Property
IT	Information Technology
ITA	Information Technology Agreement
MNE	Multinational Enterprise
OECD	Organization for Economic Co-operation and Development
TFP	Total Factor Productivity
TiVA	Trade in Value-Added
UNCTAD	United Nations Conference on Trade and Development
WTO	World Trade Organization

I. INTRODUCTION: ICT AND NATIONAL ECONOMIC INTERESTS

The United States has long recognized that open global markets benefit domestic U.S. economic interests. Trade liberalization and expansion not only encourage a more competitive domestic economy, but also reinforce the diffusion of innovation, promoting global welfare gains. In recent decades, this has had profound implications for the development of the information and communication technology (ICT) market.

ICT relates to economic welfare in many ways. It is a source of jobs and investment. It is a heavy component of trade, including export earnings, consumer value, and trade-related services opportunities. Effective use of ICT propels competitiveness, labor and capital productivity, and long-term "total factor productivity" (TFP). And ICT is increasingly central to national security, the ultimate foundation of economic confidence, risk taking, and stability.

The gains from technological change and innovation drive growth. U.S. productivity growth in the late 1990s surged as declines in ICT prices drove up capital deepening in assets that boosted innovation and efficiency. Diffusion of technology facilitated by lower prices and increasingly global supply chains allowed countries to specialize in different stages of production where they had comparative advantages.

Modern strategic realities may dictate a change in some aspects of U.S. trade liberalization policies. However, it is also certain that when governments erect barriers to global production networks, productivity will take a hit. This is especially true in the ICT sector, where policies that pull back from trade liberalization and expansion threaten to deplete gains—tangible and intangible—from open trade and investment. Over the past decade concerns have mushroomed that China was moving away from ICT globalization. The U.S. Chamber of Commerce's 2016 report, *Preventing Deglobalization: An Economic and Security Argument for Free Trade and Investment in ICT*, assessed the economic and business risks of China's efforts to develop its own ICT industry capabilities via restrictive regulations for foreign firms.

China's implementation of policies that promote ICT deglobalization hurt its economic welfare. Our 2016 simulation results showed that if Beijing decided to fully "nativize" its ICT sector, its gross domestic product (GDP) would fall somewhere from 1.8% to 3.4% annually in the least disruptive scenario.[1] In the most extreme scenario, under which productivity takes a severe hit, ICT deglobalization reduces China's GDP by as much as 10.7% to 12.3%, depending

[1] In our 2016 report, we used a static computable general equilibrium model to simulate a one-off policy shock—China's ICT goods and services imports and exports fall to close to zero—under different productivity and trade elasticity scenarios. The model estimates the impact from a baseline measured in 2015 U.S. dollars on welfare in 2016; our quantitative analysis extended assumptions about China's projected GDP growth to 2025 to estimate cumulative loss over ten years.

on how easily Chinese firms can substitute foreign ICT goods and services. Conservatively, the 1.8% hit to GDP in year one would lead to a cumulative loss of nearly $3 trillion over a decade compared with business-as-usual conditions.

Despite this warning, in the three years since our 2016 report, ICT deglobalization has become more real, as China's ICT industrial polices advanced with speed and scale. Beijing continues to implement policies including data localization, domestic encryption, and national and cyber security reviews which require indigenized manufacturing and research & development (R&D), giving preference to local actors. China is not alone in these efforts, but its decisions greatly affect the global ICT industry because of its market size and aggressive pursuit of a reduced role for non-Chinese firms.

The policy shock looming over the U.S. and global ICT landscape today arises from *American* policy action: a U.S.-China "trade war" grounded in Section 301 of the U.S. Trade Act of 1974. Building on an investigation alleging pervasive Chinese action injurious to U.S. commercial interests, and further security concerns arising from potentially hostile manipulation of the U.S. ICT infrastructure, Washington is implementing tariffs and tightening controls on U.S. technology flows. These recent policies may have different agendas: to challenge China's techno-nationalist policies that restrict market access for U.S. ICT firms; to protect sensitive and foundational technology sectors; to prevent technology transfer and cyber-enabled theft; and to offset discriminatory Chinese policies that enable unfair competition.

While U.S. action is unilateral, such concerns are broadly shared among advanced economy firms and governments. Advocates offer two main justifications for U.S. tariffs: as a near-term tool to compel a change in discriminatory Chinese efforts, or as a longer-term tool to protect U.S. security interests. In either case, they impact U.S. and global productivity in the ICT space.

In this report, Rhodium Group offers a quantitative assessment of escalation of U.S.-China tariffs under the Section 301 case. Using a dynamic computable general equilibrium (CGE) model to simulate the impact of three tariff escalation scenarios, our findings suggest:

- **Escalation of bilateral tariffs results in lower GDP, lower employment, lower investment, and lower trade flows for the United States.** The annual hit to U.S. GDP ranges from $45 billion to $60 billion in year one, and grows to a range from $89 billion to $125 billion five years later. Cumulatively, the U.S. economy stands to come up $1 trillion short of its baseline potential within ten years of tariff implementation.

- **Tariffs would not just hurt tech-intensive industries but also undermine the benefits an open ICT sector offers to the broader economy**. Milder scenarios shave up to one-third of a percentage point in TFP from real U.S. GDP growth, threatening a key channel for transmission of the benefits of an open ICT sector to the economy.

- **U.S. tariffs on Chinese goods linked to China's high-tech industrial policies would not result in meaningful onshoring of U.S. ICT production.** Domestic ICT production rises by 3-4% annually because higher prices lead to reduced imports, so domestic production must rise to meet *domestic* demand.

- **Industries built on globalized trade and production networks, including ICT manufacturing, are most exposed to negative impacts.** Within five years, U.S. ICT goods exports will be 14.2% to 20% lower than they would be otherwise, and ICT imports would fall by 9% to 10%. Exports of ICT merchandise are diverted to East Asia and Mexico, while non-ICT exports shift to European countries.

- **Higher U.S. import tariffs disproportionately hit U.S. manufacturers who rely on lower-cost inputs shipped from China.** The plurality (49%, $113 billion) of U.S. imports from China subject to new tariffs are intermediate goods, which comprise semi-finished goods used as inputs in the production of final products.

- **Tariffs reroute global ICT supply chains to regional supply chains.** In all scenarios, ICT merchandise production falls in China and grows in Canada and Mexico. While East Asian countries would experience a boost in ICT merchandise production, other Asian countries see lower-than-baseline output.

- **ICT services are indirectly affected by tariffs due to their critical role in facilitating all goods trade, and especially within highly fragmented supply chains**. The impact on the U.S. ICT services sector is not as immediate as in ICT manufactures but grows more severe over time and equates to a significant missed opportunity for the U.S. ICT services industry.

- **Because both the United States and China are highly integrated into global value chains—and are the most integrated in ICT industries—they stand to lose the most in investment, trade, and welfare from the imposition of bilateral tariffs.** Downgrades to Chinese and U.S. GDP lead to global growth that is $151.4 billion (0.2%) lower than projected in 2025 if U.S. tariffs on Chinese exports worth $200 billion increase to 25% and China retaliates. The biggest beneficiaries, in GDP terms, from escalation of bilateral tariffs are Canada and Mexico.

Our quantitative analysis only examines the impact of bilateral tariffs; we supplement the modeling work with a qualitative assessment of U.S. and ICT sub-industry exposure to other current policies that stand in contrast to more recent U.S. efforts to liberalize and expand trade. We assess U.S. tariffs hurt U.S. manufacturers in global supply chains in which China and the United States have an outsized presence. This implicates both producers of computer, electronic, and optical products, as well as U.S. services providers in the ICT space and in

sectors facilitating ICT merchandise trade. U.S. tariffs on imports from China also tax shipments from U.S. and other foreign affiliates located in China.

Tariffs are a precursor to a broader response among advanced economies to a China no longer as convergent with market norms. Further ICT deglobalization is highly likely (as is evident daily), and a sustained return to deeper engagement will require a decisive Chinese reform course correction. Not everyone agrees with the full thrust of U.S. trade policy, and many interested observers have complaints about the current campaign. But pushback to China's industrial policies, particularly in the ICT sector, predates the Trump era, and is likely to endure beyond it. To that end, we conclude with a qualitative assessment of the key policies, outside the scope of the Section 301 case and extending beyond tariffs, that have implications for the U.S. and global economy.

II. ASSESSING THE ECONOMIC IMPACT OF U.S. ICT DE-GLOBALIZATION POLICIES

The global ICT revolution is arguably the most important force in generating global economic growth in the modern era. One of the main channels is through enhancing productivity—that is, expanding the limits that efficient allocation of resources can achieve. As a "general purpose" technology, ICT has triggered technological advancement and innovation across many sectors. Globalization in turn facilitates the diffusion of technology across borders, further promoting innovation, creating knowledge spillovers, and spreading potential growth.

The United States has been a primary enabler of the productivity growth associated with technological advancement, both through innovation and through replication of technologies. Economic literature points to the role that information technology (IT) hardware—and computer hardware in particular—played in growing the economy. Falling computer and semiconductor prices generated by rapid improvements in semiconductor technology prompted the investment boom in IT hardware and software during the period 1995-2000.[2] After that, technological diffusion and ICT adoption progressed in office and computing equipment and communication equipment, followed by increased investment in software.[3]

As a result, innovation in IT-producing industries led to a boom in productivity growth; the computer equipment manufacturing industry alone generated 2.7% of U.S. economic growth from 1960 to 2007 and 25% of its productivity growth, most of which occurred in the mid-1990s.[4] From 2000 to 2007, IT-*using* (rather than producing) industries, including many key service industries, became the main source of sustained U.S. productivity growth.[5] ICT-producing industries spread productivity gains to other countries, accounting for two-thirds of total business sector TFP in Germany, the United Kingdom and Slovenia, and just below 50% in France and the Netherlands from 1996 to 2007.[6] Our 2016 report examined the ways in which the global ICT revolution contributed to a deepening of China's economic connectedness and boosted its TFP growth potential. We estimated TFP contributed around three percentage points to China's GDP in 2015, with two-thirds of that dependent on ICT-related activity.[7]

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[2] Dale Jorgenson et al., "Information Technology and U.S. Productivity Growth: Evidence from a Prototype Industry Production Account," *Industrial Productivity in Europe: Growth and Crisis*, Matilde Mas and Robert Stehrer (eds.), November 19, 2010. https://scholar.harvard.edu/files/jorgenson/files/02_jorgenson_ho_samuels19nov20101_2.pdf.

[3] Vincenzo Spiezia, "ICT investments and productivity: Measuring the contribution of ICTS to growth", *OECD Journal: Economic Studies* Vol. 2012/1, p. 202. http://search.oecd.org/eco/growth/ICT-investments-and-productivity-measuring-the-contribution-of-ICTS-to-growth.pdf.

[4] Dale Jorgenson et al., "Information Technology and U.S. Productivity Growth: Evidence from a Prototype Industry Production Account," *Industrial Productivity in Europe: Growth and Crisis*, Matilde Mas and Robert Stehrer (eds.), November 19, 2010, p. 2. https://scholar.harvard.edu/files/jorgenson/files/02_jorgenson_ho_samuels19nov20101_2.pdf.

[5] Dale Jorgenson et al., "Information Technology and U.S. Productivity Growth: Evidence from a Prototype Industry Production Account," *Industrial Productivity in Europe: Growth and Crisis*, Matilde Mas and Robert Stehrer (eds.), November 19, 2010, p. 18. https://scholar.harvard.edu/files/jorgenson/files/02_jorgenson_ho_samuels19nov20101_2.pdf.

[6] Vincenzo Spiezia, "ICT investments and productivity: Measuring the contribution of ICTS to growth", *OECD Journal: Economic Studies* Vol. 2012/1, p. 202. http://search.oecd.org/eco/growth/ICT-investments-and-productivity-measuring-the-contribution-of-ICTS-to-growth.pdf.

[7] U.S. Chamber of Commerce, "Preventing Deglobalization: An Economic and Security Argument for Free Trade and Investment in ICT," 2016, pg. 77-78. https://www.uschamber.com/sites/default/files/documents/files/preventing_deglobalization_1.pdf.

Trade liberalization has amplified the productivity gains from ICT. A prime example is the Information Technology Agreement (ITA), which liberalized trade in products including computers, semiconductors, telecommunication equipment, and software. As a result, global IT trade tripled between 1996 and 2014.[8] The most recent expansion of the ITA in 2015 covers as much as 99% of the value of global ICT merchandise imports.[9]

The lowering of direct tariff costs and indirect non-tariff barrier costs through trade liberalization and advances in technology and logistics contributed to the emergence of global supply chains (GSCs), allowing different economies to specialize in different stages of production, relying on extensive trade flows with minimal border costs.[10] Global supply chains are not only beneficial to trade and investment flows; services account for more than half of value creation in global value chains among Organization for Economic Co-operation and Development (OECD) economies.[11] On a macro level, participation in global supply chains can increase economic welfare in two main ways: by increasing producer profits through specialization in areas where they have comparative advantage, and by lowering prices for consumers.

Global supply chains can also multiply the costs of protectionism and other inefficiencies. Each time a good crosses a border, it faces duties, inspections, certifications, and other nontariff measures. Sometimes the costs of crossing a border may outweigh the value-added at that stage of production. Unpredictable delays can result in additional costs such as storage fees, depreciation, or manufacturing disruptions.[12] The more fragmented a supply chain, the more sensitive it is to tariffs and other border costs.

U.S. and China in Global Value Chains

The United States and China are the most important links in ICT global value chains. This is apparent not just in traditional metrics of trade and investment, but also in terms of the value-added by workers and companies not easily captured in trade flows. The difference between the cost of intermediate inputs a firm receives, and the price paid by the next link in the chain—be it a firm or a consumer—is called value-added. The OECD maintains the most widely used database of trade in value-added (TiVA) for understanding value creation across borders based on global input-output tables.

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[8] Gary Hufbauer et al., "From Drift to Deals: Advancing the WTO Agenda," Peterson Institute for International Economics, June 2015, p. 18. https://piie.com/publications/papers/hufbauer-etal201506ICC.pdf.

[9] UN Conference on Trade and Development, "Trade in ICT Goods and the 2015 Expansion of the WTO Information Technology Agreement," Technical Note No. 5, TN/UNCTAD/ICT4D/05, December 2015, p. 5. https://unctad.org/en/PublicationsLibrary/tn_unctad_ict4d05_en.pdf.

[10] U.S. International Trade Commission, "The Economic Effects of Significant U.S. Import Restraints," Ninth Update, September 2017, p. 131-132. https://www.usitc.gov/publications/332/pub4726.pdf.

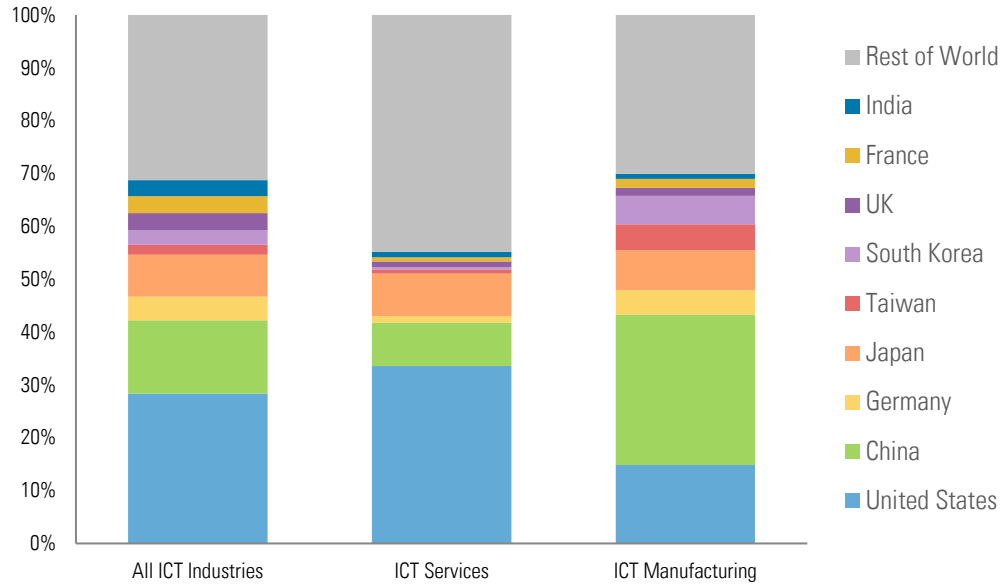
[11] OECD, "Interconnected Economies: Benefiting from Global Value Chains," May 2013. https://www.oecd.org/mcm/C-MIN(2013)15-ENG.pdf.

[12] U.S. International Trade Commission, "The Economic Effects of Significant U.S. Import Restraints," Ninth Update, September 2017, p. 19. https://www.usitc.gov/publications/332/pub4726.pdf.

As Figure 1 shows, the United States alone contributes more than a quarter of the value of final demand in ICT industries as defined by the OECD. In ICT services, the U.S. contributes more value than any other country. China, by contrast, adds the most value in ICT manufacturing industries, accounting for nearly 30% of the total.[13]

Figure I: Value-Added by Source Country in Final Demand for ICT-Related Industries, 2015*

Share of total



Source: OECD Trade in Value-Added database. Last updated December 2018. In its definition of ICT industries, the OECD includes Computers, Electronics, and Optical Products Manufacturing; Publishing, Audio-Visual, and Broadcasting Activities; Telecommunications Services; and IT and Other Information Services. The remaining subsectors are included here for relevance to the ICT industry.

China and the United States participate differently in GVCs. The United States participates in higher-value segments heavy in innovation and R&D, relying on lower-cost foreign manufacturers for processing and assembly, and importing final goods with lower-value foreign inputs. According to OECD's TiVA data, 25% of domestic value-added in U.S. gross exports went into the exports of third countries—higher than average for developed countries. In other words, the United States has a high "forward participation" rate, in that it contributes relatively more value to the exports of other countries through GVCs.

As of 2015, China was the top exporter of U.S. value-added through GVCs.[14] Some of that value returns to the United States in its imports from China. In 2015, 2% of the value in China's total

[13] For more information on OECD's TiVA stats, see https://stats.oecd.org.
[14] World Trade Organization, "Trade in Value-Added and Global Value Chains," United States profile, 2011.

exports to the United States actually originated in the United States. The share of U.S. value is higher, around 3.2%, in U.S. imports of ICT-related goods and services from China.

While the United States leads in higher-value GVC segments, China falls on the other side of the spectrum. Only 15% of its domestic value-added is forwarded in third-country exports, lower than developing economies (23%). By contrast, China maintains a high level of "backward participation" in GVCs, meaning it relies on processing and assembling imported components without adding much value as finished products leave its borders. As of 2015, more than 32% of the value of its gross exports came from foreign countries. Across industries, China most relies on foreign inputs in its gross exports of computer and electronics manufacturing, with 40.7% of Chinese exports containing foreign content.[15] As of 2011, the top contributors of value to China's gross exports were Japan (14.7%), the United States (9.4%), and South Korea (8.3%).

China is moving up the value chain. Foreign firms (excluding those in Hong Kong, Macau, and Taiwan) accounted for 20% of patents filed and R&D spending in 2005, but as of 2016 account for around 15%.[16] Chinese firms strongly increased their participation in innovative activities starting in 2013, accounting for around three-quarters of patents filed and R&D spending in 2016.[17] While the foreign firm share of China's ICT hardware exports decreased from 69% in 2005 to 45% in 2016, domestic firms still only accounted for 21% of 2016 ICT hardware exports from China. Firms based in Hong Kong, Macau, and Taiwan account for the remaining one-third.

ECONOMIC TRENDS IN U.S.-CHINA ICT ENGAGEMENT

U.S.-China ICT Goods Trade

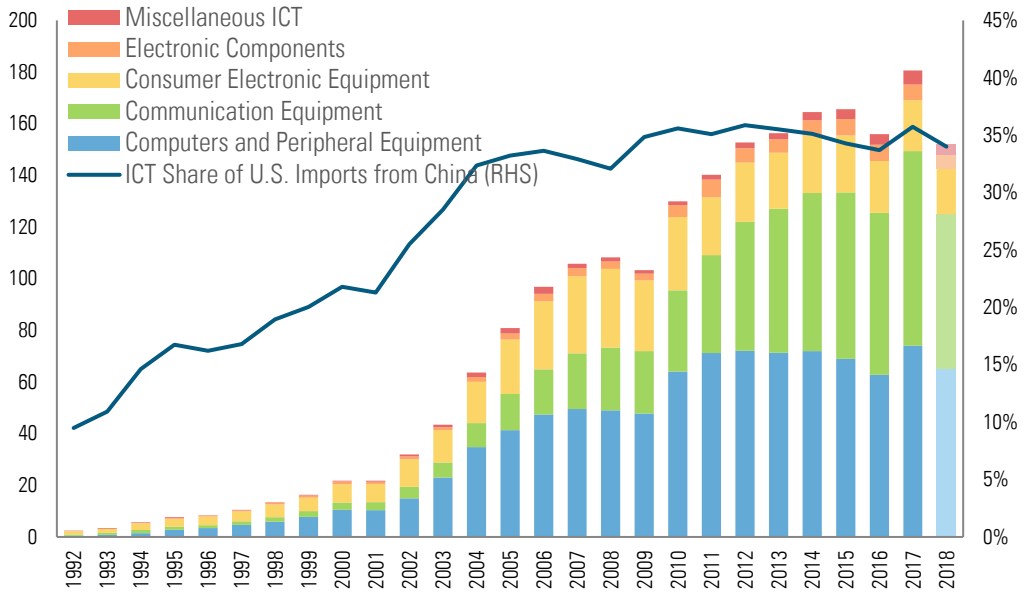
Two-way goods trade between the U.S. and China has risen seven-fold since China's World Trade Organization (WTO) accession, and today the United States is the biggest destination for China's exports. ICT is a centerpiece of bilateral merchandise trade expansion, accounting for nearly one-third of gross bilateral goods trade in 2017. China's implementation of the ITA in 2006—after a three-year tariff phase-out period—propelled it to become an IT-exporting powerhouse. By 2010, China had eclipsed both the U.S. and the EU as the world's top IT exporter. Since ITA accession, China has developed from a downstream processing hub that mainly exports final goods to exporting more intermediate ICT products.[18]

[15] World Trade Organization, "Trade in Value-Added and Global Value Chains," China profile, 2011.
[16] Tables 1-1-6 to 1-1-8, "Statistics on Production and Management in High-tech Industry" by Enterprise Type and Industrial Sector, *China's High-Technology Statistical Yearbook 2017*, National Bureau of Statistics Department of Social, Science and Technology, and Cultural Statistics, China Statistics Press 2017.
[17] However, the vast majority of Chinese patents are utility model, which have a lower level of inventiveness.
[18] World Trade Organization, "The Effects of Liberalization under the ITA," Chapter 1 in *20 Years of the Information Technology Agreement: Boosting Trade, Innovation, and Digital Connectivity*, 2017. https://www.wto.org/english/res_e/booksp_e/ita20years_2017_chap1_e.pdf.

The composition of bilateral ICT trade flows mirrors China's arrival in global supply chains. As Figure 2 shows, U.S. ICT goods imports from China totaled around $180 billion in 2017, rising to 36% of total U.S. imports from China from 21% in 2001. Since 2010, annual American imports of Chinese computers and peripheral equipment have remained relatively constant, while communication equipment have driven increasing ICT imports from China. Mobile phones and switching and routing apparatus were the two biggest contributors, rising $32.7 billion and $18.6 billion over the decade from 2007 to 2017, respectively.

Figure 2: U.S. ICT Imports from China and ICT Share of Total U.S. Imports from China, 1992-2018*

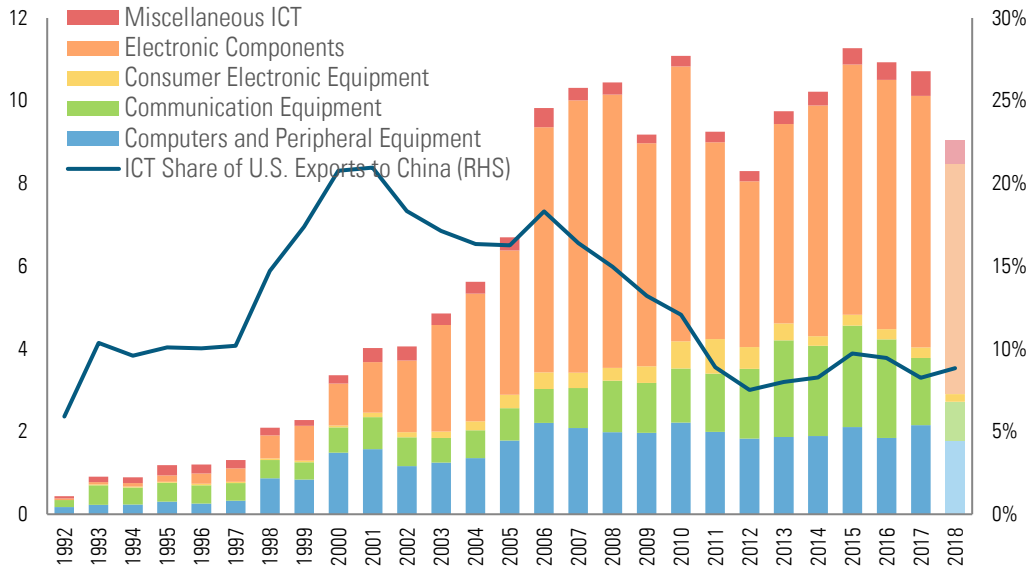
USD billion (LHS), percent (RHS)



Source: U.S. Census Bureau. *2018 data through October. ICT products are categorized based on UNCTAD classification system, which is updated every five years.

ICT merchandise accounts for only 8-9%, or $11 billion annually, of total U.S. merchandise exports to China, peaking around 21% in 2001 (Figure 3). While mobile and telecom equipment drove China's ICT exports to the U.S., electronic components drove its ICT imports from the U.S. after 2001. This surge is almost entirely driven by electronic integrated circuits, or microchips, that are intermediate inputs to other electronic goods processed and assembled by China for re-export.

Figure 3: U.S. ICT Exports to China and ICT Share of Total U.S. Exports to China, 1992-2018*
USD billion (LHS), percent (RHS)



Source: U.S. Census Bureau. *2018 data through October. ICT products are categorized based on UNCTAD classification system, which is updated every five years.

In terms of trade complementarity, i.e. the extent to which a country's export profile matches the import profile of its partner, U.S.-China trade was well-matched for many years. Since 2000, China's export profile has increasingly matched the U.S. import structure; for the U.S., however, the opposite trend has taken hold, where its exports are less suited to China's evolving import structure. In other words, goods in which the U.S. is most competitive in global export markets are not necessarily those China needs to import, at least not in sufficient volumes to balance bilateral trade.

U.S.-China ICT Services Trade

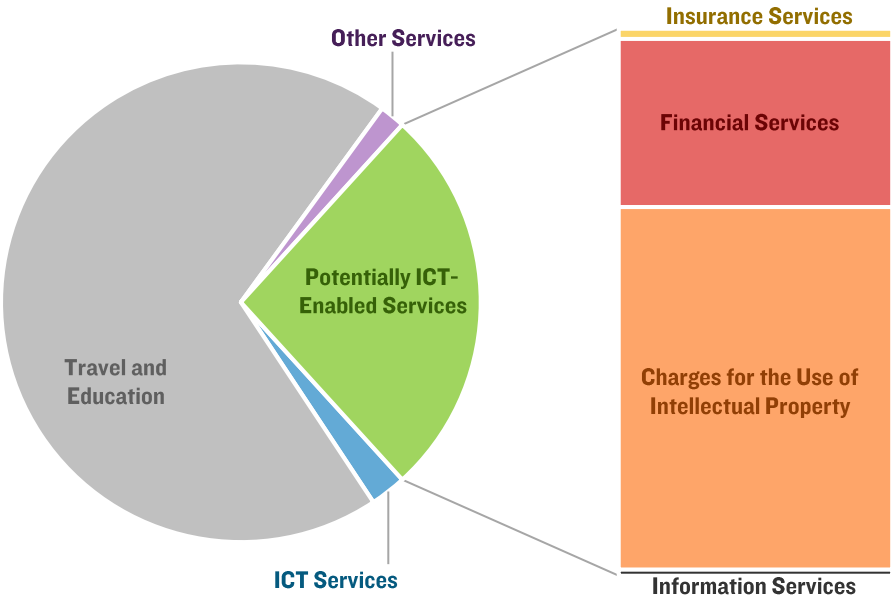
While the U.S.-China goods trade deficit grabs headlines, services trade represents a significant burgeoning market for American companies. Technological advancement and reductions in ICT costs over time created more opportunities for the provision of services remotely across international borders, but Chinese policies restrict the free flow of commercial data and limit foreign access. Thus, ICT deglobalization is not just a story about closing down tech trade; it also impacts potential ICT-enabled cross-border services flows.

The United States has a $40 billion services trade surplus with China, but Chinese spending on tourism and education in America accounts for most of it (Figure 4). ICT services—which includes telecommunications services, computer services, and charges for the use of

intellectual property embedded in U.S. software—accounted for only 2.5% of the U.S. surplus in 2017.

Figure 4: Key Components of the U.S.-China Services Trade Surplus, 2017*

Share of total



Source: U.S. Bureau of Economic Analysis. *Negative services subsector balances were added into the Travel and Education surplus and not displayed here to better account for shares of the total balance. Potentially ICT-Enabled Services includes insurance services, financial services, charges for the use of intellectual property excluding software (which is included in ICT services), information services, and other business services including R&D, professional and management consulting, architectural and engineering services, industrial engineering, and training services.

Potentially ICT-enabled services,[19] broadly defined as services delivered remotely over ICT networks, can include almost any type of service: royalty payments on other forms of intellectual property, insurance, financial services, other business services, and R&D, to name a few. (For many types of services trade flows, the mode of delivery is unknown, so the term "potentially" applies.) As Figure 4 shows, potentially ICT-enabled services account for about one-quarter of the U.S. services surplus with China, but some subsectors including insurance and information services maintain only minor surpluses.

[19] "Potentially ICT-Enabled Services" is not well-defined. The U.S. Bureau of Economic Analysis includes a variety of services in this category including insurance services, financial services, charges for the use of intellectual property excluding software (which is included in ICT services), information services, and other business services including R&D, professional and management consulting, architectural and engineering services, industrial engineering, and training services. Alexis N. Grimm, "Trends in U.S. Trade in Information and Communications Technology (ICT) Services and in ICT-Enabled Services," Bureau of Economic Analysis, May 2016. https://apps.bea.gov/scb/pdf/2016/05%20May/0516_trends_%20in_us_trade_in_ict_serivces2.pdf.

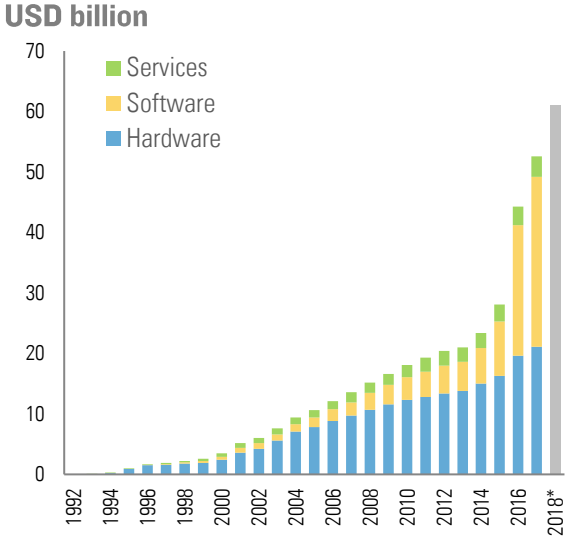
ICT services is one of the biggest potential drivers of trade and investment flows between the United States and China, but significant barriers remain including policies requiring source code reviews and/or joint ventures with domestic competitors, along with risk of intellectual property theft. Maintaining a commercial presence in the service recipient country is the most important channel for services trade worldwide, but foreign equity caps and other market access barriers in China inhibit foreign service providers from delivering services locally. These limitations constrain the willingness of foreign providers to offer new technologies to the China market in promising emerging ICT sectors like big data and cloud computing and are central to the current bilateral trade conflict.

U.S.-China ICT Investment

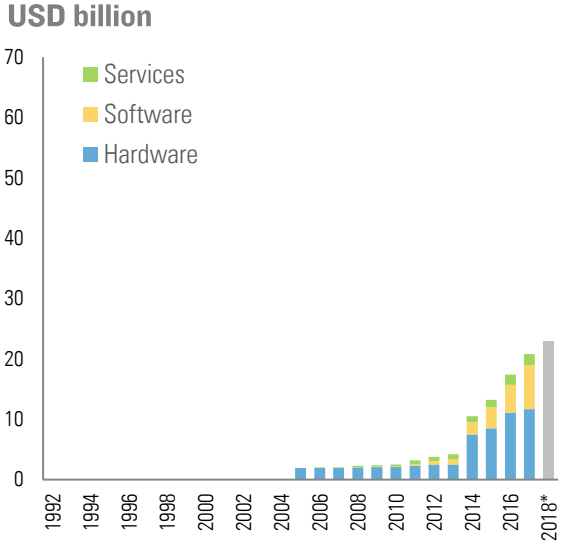
Over the past 30 years, ICT has been the biggest single-sector destination for U.S.-China investment, totaling $74 billion or 15% of cumulative bilateral investment flows from 1990 to 2017. As Figure 5.1 shows, the composition of U.S. ICT investment in China has changed over time. Historically, hardware accounted for most of the stock of U.S. ICT investment—including foreign direct investment (FDI), venture capital, and other equity investment—in China, as U.S. companies localized manufacturing facilities to take advantage of cheaper labor and land costs. Since 2015, U.S. investment in software has surged, while investment in ICT services is nascent in comparison but growing.

Figure 5: U.S.-China ICT Investment by Sector, 1992-2018*

5.1 Cumulative U.S. ICT Investment in China



5.2 Cumulative Chinese ICT Investment in the U.S.



Source: Rhodium Group. *Includes FDI (acquisitions and greenfield investments of at least 10% stake involving mainland Chinese companies) as well as venture capital and other non-FDI equity investments involving companies headquartered in mainland China; deals are coded by the primary sector; investment value recorded at historical value; 2018 value estimated.

The stock of Chinese ICT investment in the United States is only one-third the size of the U.S. ICT investment stock in China but took off starting in 2013 (Figure 5.2) reinforced by strong incentives from Beijing for its firms to invest in global ICT assets to access technology and increase their competitiveness. This surge was partially driven by an increase in venture capital (VC) investment. Cutting-edge technologies have been a key target for Chinese VC investment in the United States; three-quarters of investors in 2017 targeted the ICT or health, pharmaceuticals and biotechnology industries.[20] Increasing inbound ICT investment from China is mirrored by concerns and new policy activism among OECD economies about Chinese policies designed to scale up participation in high-tech sectors through investment channels.

KEY DEVELOPMENT IN ICT DEGLOBALIZATION: U.S. SECTION 301 CASE

Today's policy shock looming over the U.S. and global ICT landscape arises from American policy action: a U.S.-China "trade war" grounded in Section 301 of the U.S. Trade Act of 1974. Building on an investigation alleging pervasive Chinese action injurious to U.S. commercial and national security interests, Washington is implementing tariffs and tightening controls on U.S. technology flows to remedy concerns about China's techno-nationalist policies and the need to protect sensitive and foundational technology sectors, prevent technology transfer and cyber-enabled theft, and offset discriminatory Chinese policies that enable unfair competition. While U.S. action is unilateral, such concerns are broadly shared among advanced economy firms and governments.

Under the Section 301 case, the United States and China imposed tariffs covering more than half the value of gross bilateral trade. Tariff implementation proceeded in three waves in 2018 (see Table 1). The initial set of 25% tariffs on $50 billion in goods trade each way was implemented in two rounds, with U.S. tariffs concentrated in goods containing "industrially significant technology" linked to the 'Made in China 2025' industrial policy. China's retaliatory tariffs focused mainly on U.S. agricultural and energy commodities. New tariffs levied in these two rounds cover 15% of the value of gross bilateral trade, based on 2017 data. The third round of tariff escalation, effective September 2018, covers more than half the value of two-way trade flows.

Both U.S. and Chinese tariffs directly implicate the ICT sector. More than half (53.1%) of total U.S. ICT goods imports from the world in 2017 came from China; now, one-third of those—equivalent to 17.7% of total U.S. ICT merchandise imports from the world—are subject to 10-25% Section 301 duties. Of the $60 billion in U.S. ICT imports from China subject to Section 301 tariffs, around $8 billion are subject to 25% tariffs, and $52 billion to 10% tariffs. This mirrors the stated approach by the USTR in vetting goods for tariff application targeted at 'Made in China 2025'.[21]

[20] Thilo Hanemann, Adam Lysenko, and Daniel H. Rosen, "Chinese Venture Capital in the US: Recent Trends and FIRRMA Impacts," Rhodium Group, July 11, 2018.
[21] Office of the U.S. Trade Representative, "USTR Issues Tariffs on Chinese Products in Response to Unfair Trade Practices," June 15, 2018. https://ustr.gov/about-us/policy-offices/press-office/press-releases/2018/june/ustr-issues-tariffs-chinese-products.

Table I: Key Dates in U.S.-China 2018 Tariff Implementation under Section 301 Case

EFFECTIVE DATE	ACTION	TARIFF DETAILS
ROUND 1: JULY 6, 2018	U.S. imposes 25% tariff on $34 billion in Chinese imports	Includes products identified as containing "industrially significant technology"
	China imposes 25% tariff on $34 billion in U.S. imports	Includes agricultural goods, autos and auto parts, and aquatic products
ROUND 2: AUGUST 23, 2018	U.S. imposes 25% tariff on $16 billion in Chinese imports	Includes products identified as benefiting from Chinese industrial policies including 'Made in China 2025'
	China imposes 25% tariff on $16 billion in U.S. imports	Includes chemical products, medical equipment, and energy products
ROUND 3: SEPTEMBER 24, 2018	U.S. imposes 10% tariff on $200 billion in Chinese imports	Wide range of goods including tobacco, chemicals, small manufactures
	China imposes 5-10% tariffs on $60 billion in U.S. imports	Includes agricultural, food, chemical, textile, metal, and electrical equipment products
ROUND 4: TO BE DETERMINED	U.S. threatened to raise the 10% tariff on $200 billion in Chinese imports to 25% if no agreement reached	Includes same product list at Round 3.

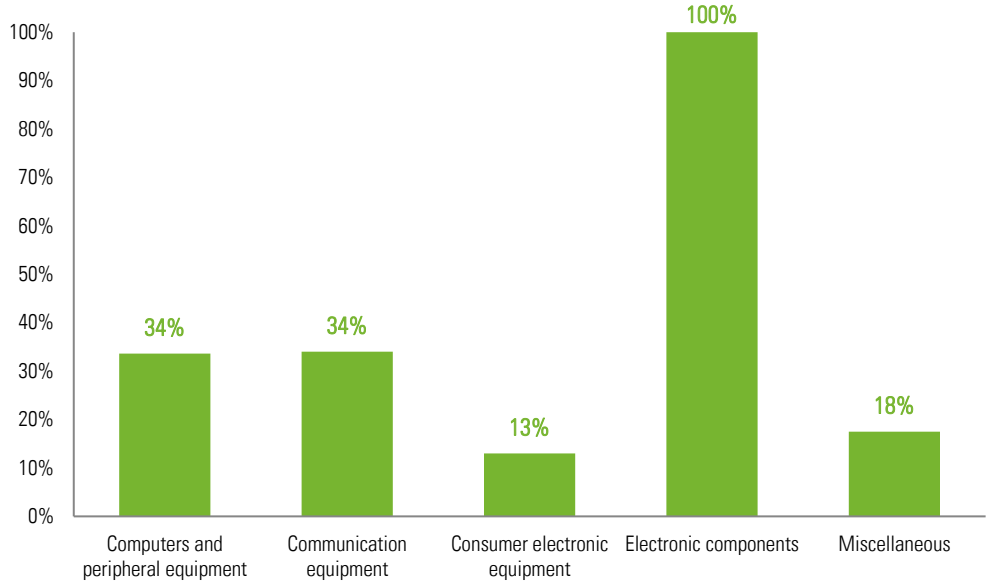
Source: U.S. Trade Representative's Office, Ministry of Commerce.

The ICT tariffs vary in their coverage on different ICT sub-industries (see Figure 6). All U.S. electronic component imports from China are subject to the tariffs, yet those goods only amount to 13% of total U.S. imports of electronic components from the world. (Electronic components are one of the smallest categories of U.S. ICT imports from China.)

In two ICT goods categories—computers and peripheral equipment, and communication equipment—more than one-third of U.S. imports from China are subject to Section 301 tariffs. These two categories comprise the biggest components of overall U.S. ICT imports from China, totaling around $150 billion in 2017—equivalent to more than one-fifth of global U.S. imports of those goods. This could suggest less flexibility among U.S. importers in diversifying sources of computers and communication equipment.

Figure 6: U.S. ICT Imports from China Subject to Section 301 Tariffs by ICT Sub-Category*

Share of 2017 import value



Source: U.S. Census, UNCTAD, USTR. *Import data based on 2017 USD values. Product classification based on HS 2017 standard. U.S. tariff rates range from 10% to 25%.

While China's reciprocal tariffs apply to U.S. ICT exports, the scale is smaller than U.S. tariffs on China's ICT exports. The share of American ICT merchandise exports destined for China has remained in the range of 7%-9% over the past five years. The sub-industry impact of China's retaliatory tariffs on U.S. ICT goods exports is less clear, primarily due to the mismatch in product classification systems and data availability at a granular level.[22] What we do know is that it was not until the most recent round of tariff retaliation ($60 billion, in September 2018) that China subjected any U.S. ICT good to new tariffs. Around 4% (or 213 items) of the 5,000 line items subject to third-round tariffs are classified as ICT goods. Based on our approximation, all ICT subcategories except electronic components—the biggest U.S. ICT subsector export to China, containing integrated circuits—were impacted by China's retaliatory tariffs. This speaks to Chinese manufacturers' reliance on American cutting-edge technology.

The tariffs also impact different stages of production. The plurality (49%, $113 billion) of U.S. imports from China subject to new tariffs are intermediate goods, which comprise semi-finished goods used as inputs in the production of final products. Fifty-eight percent of the 6,000 tariff line items hit with Chinese retaliatory tariffs are classified as intermediate goods,

[22] Both the U.S. and China report tariffs by 8-digit product code. The Harmonized System for merchandise classification mandates international consistency at the 6-digit level but allows individual countries to use additional digits for classification. The U.S. classifies goods with the HTS system of 10-digit codes. China does not publicly report merchandise trade by partner and product code, but most unofficial classification catalogues use 10-digit codes. For this reason, U.S.-China export data cannot be matched fully at the 8-digit tariff line level.

while capital goods and consumer goods each account for 17% of the total number of goods subject to tariffs.

MODELING U.S.-CHINA TARIFFS

To assess the economic impacts of U.S.-China tariffs, we used the GTAP (Global Trade Analysis Project) CGE model, which has been used extensively for global-scale policy impact analysis since the early 1990s by governments, research institutes, and economists around the world.[23] GTAP combines economic theory and empirical data to account for all trade flow interactions among industries, consumers, and countries globally.

The model simulates the effects of trade policy changes on endogenous variables—those whose values are solved for by the model: prices, production, consumption, exports, imports, investment, and welfare. The difference in the values of the endogenous variables between the projected baseline scenario and the simulated scenarios represents the effect of policy change.

Defining the Scenarios and Calibrating the Model

We model three scenarios of U.S.-China Section 301 tariff escalation based on actual proposals from each side (see Table 2). The "partial" escalation scenario, effective as of August 2018, includes bilateral 25% tariffs covering $100 billion in annual two-way trade, equivalent to 15% of the value of gross bilateral trade in 2017. The second scenario, named "half" escalation because it implicates more than half the value of gross bilateral trade, includes additional 25% U.S. tariffs on $200 billion in imports from China and 5-25% Chinese tariffs on imports from the U.S. worth $60 billion annually. The "full" escalation scenario simulates 25% tariffs on all bilateral goods trade.

Because tariff escalation advanced quickly in 2018, the modeled "half" escalation scenario is different from tariffs effective as of February 2019. Our "half" escalation scenario is based on Washington's July 2018 proposed list of more than 6,000 tariff lines adding up to $200 billion in imports from China, and Beijing's proposed retaliatory tariffs of 5-25% on $60 billion in U.S. imports. After a public hearing process, in September 2018 the United States applied 10% duties on a subset of that list; more than 200 tariff lines were removed, including some ICT goods. In response Beijing also pared down its initially proposed list and limited tariff rates to 5-10%.

[23] For more information on model methodology, see the appendix to this report.

Table 2: Modeled U.S.-China Tariff Escalation Scenarios

SCENARIOS	DESCRIPTION	STATUS
1. PARTIAL	25% U.S. tariffs on $50 bn of Chinese imports; 25% Chinese tariffs on $50 bn U.S. imports.	Fully in force as of Aug 23, 2018.
2. HALF	Partial scenario, plus 25% U.S. tariffs on $200 bn of Chinese imports, and 5-25% Chinese tariffs on $60 bn in U.S. imports.	Partially in force as of Sept 24, 2018. U.S. tariffs of 10% and Chinese tariffs of 5-10% apply to a subset of the proposed list.
3. FULL	25% tariffs on all bilateral merchandise trade.	In July 2018, President Trump threatened to impose tariffs on all U.S. imports from China.

The model examines the Section 301 case alone and does not capture the potential impact of other recent U.S. policies. For example, U.S. tariffs on imports of steel and aluminum, levied in June 2018 under Section 232 of the Trade Expansion Act of 1962, have indirect implications for the ICT sector (namely, higher input costs) but were not considered here. In addition, while the model captures dynamic changes in capital stock based on expected and actual rates of return on investment—that is, tariffs raise import prices, resulting in less wherewithal to invest in capacity over time—it does not capture the hit to investment from bearish investor sentiment or uncertainty resulting from application of tariffs.

U.S. Macroeconomic Impacts

In all three scenarios, escalation of bilateral tariffs results in lower GDP, lower employment, lower investment, and lower total exports and imports for the United States. The variables that downgrade potential economic growth are primarily exports and investment. This is because tariffs drive up import and export prices, thereby reducing trade flows both ways. Higher prices reduce competitiveness and hurt firms' investment in production capacity over time, thereby lowering productivity and economic growth. Productivity also falls due to less efficient resource allocation.

The full extent of the potential fall in U.S. GDP is offset by lower imports and higher consumption of domestically-produced substitutes. On net, consumption of domestic output in our model increases, but "absorption"—the whole of domestic demand for both domestic and imported products—weakens significantly.

Aggregate U.S. production falls, but the net impact varies by sector—there are both winners and losers, as tariffs shelter some industries from competition. In theory, sectors dependent on imported inputs, or final goods that are relatively import-dependent, suffer more under costlier inputs. This is reflected by the large reduction in ICT goods exports. As a result, more

U.S. ICT production happens at home (or in other non-tariff countries), as domestically-produced goods face lower competition from imports.

Table 3 summarizes the impact of bilateral tariffs on the U.S. economy across a selection of key macroeconomic variables. In assessing broader aggregate costs to the U.S. economy, we discuss three variables in this section: national production (GDP), TFP, and gross national consumption ("absorption").

Table 3: Summary of Impacts on the U.S. Economy

Percent deviation from baseline

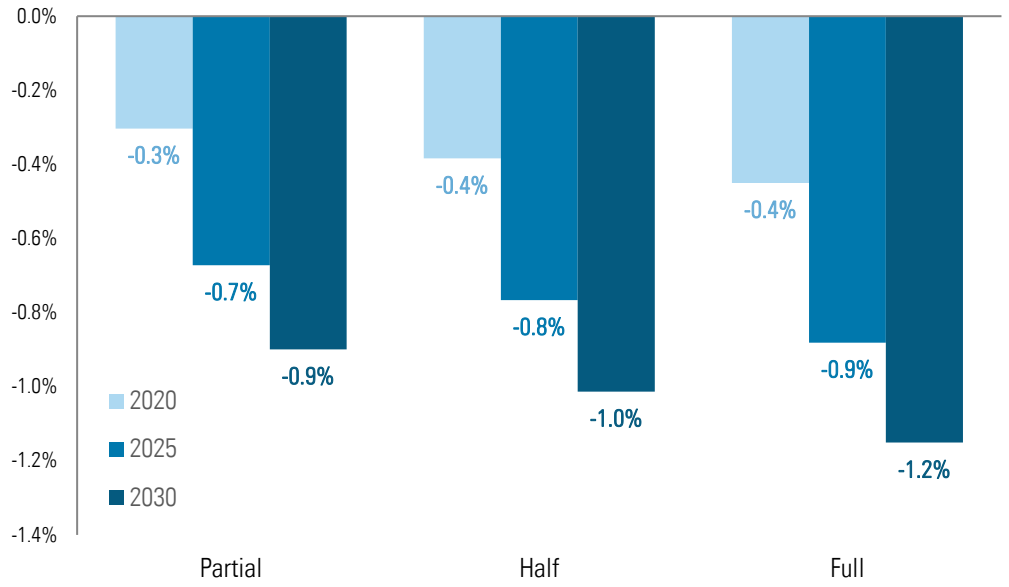
VARIABLE	2020			2025			2030		
	Partial	Half	Full	Partial	Half	Full	Partial	Half	Full
GDP	-0.3%	-0.4%	-0.4%	-0.7%	-0.8%	-0.9%	-0.9%	-1.0%	-1.2%
Exports	-4.8%	-4.4%	-6.7%	-5.1%	-4.6%	-6.9%	-6.8%	-6.3%	-8.8%
Exports of ICT Goods	-13.6%	-13.8%	-19.4%	-14.6%	-14.9%	-20.2%	-17.8%	-18.1%	-23.7%
Exports of ICT Services	-0.5%	-0.6%	-0.4%	-1.2%	-1.3%	-1.1%	-3.6%	-3.7%	-3.7%
Imports	-3.6%	-3.3%	-5.1%	-4.1%	-3.8%	-5.8%	-3.7%	-3.3%	-5.4%
Imports of ICT Goods	-9.0%	-7.5%	-10.7%	-8.8%	-7.2%	-10.3%	-7.2%	-5.5%	-8.5%
Imports of ICT Services	0.6%	0.6%	0.6%	0.8%	0.8%	0.7%	1.8%	1.8%	1.8%
Investment	-5.5%	-5.6%	-6.3%	-6.6%	-6.6%	-7.4%	-4.5%	-4.5%	-5.2%
Inflation*	0.63	0.67	0.98	0.64	0.69	0.92	1.02	1.06	1.28
Domestic Consumption	1.1%	1.0%	1.1%	1.0%	0.9%	0.9%	0.6%	0.5%	0.5%
Employment	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%	-0.3%	-0.3%	-0.3%	-0.4%
Production of ICT goods	3.5%	3.9%	4.4%	2.8%	3.2%	3.7%	3.1%	3.5%	4.3%
Production of ICT services	0.6%	0.5%	0.6%	0.2%	0.1%	0.2%	-0.3%	-0.4%	-0.4%

Source: GTAP, RHG calculations. *Inflation shown as percentage point change in cumulative inflation.

In Figure 7, we show the projected deviation from business-as-usual U.S. GDP under three scenarios of bilateral tariff escalation. In the "partial" escalation scenario, under which U.S. tariffs on $16 billion in Chinese imports were concentrated in ICT components explicitly related to the 'Made in China 2025' industrial policy, the annual downgrade ranges from 0.3% below baseline GDP ($60.7 billion) in 2020 to 0.7% ($145.3 billion) in 2025. The "half" escalation scenario will take a $77 billion (0.4%) bite out of baseline U.S. GDP the year after it takes effect, and within ten years the annual hit is equivalent to $237 billion. Across all scenarios, by 2030 the impact deducts between $210.5 billion (0.9%) and $269.5 billion (1.2%) from annual GDP.

Figure 7: Impact on Annual U.S. GDP under Tariff Escalation Scenarios, 2020-2030

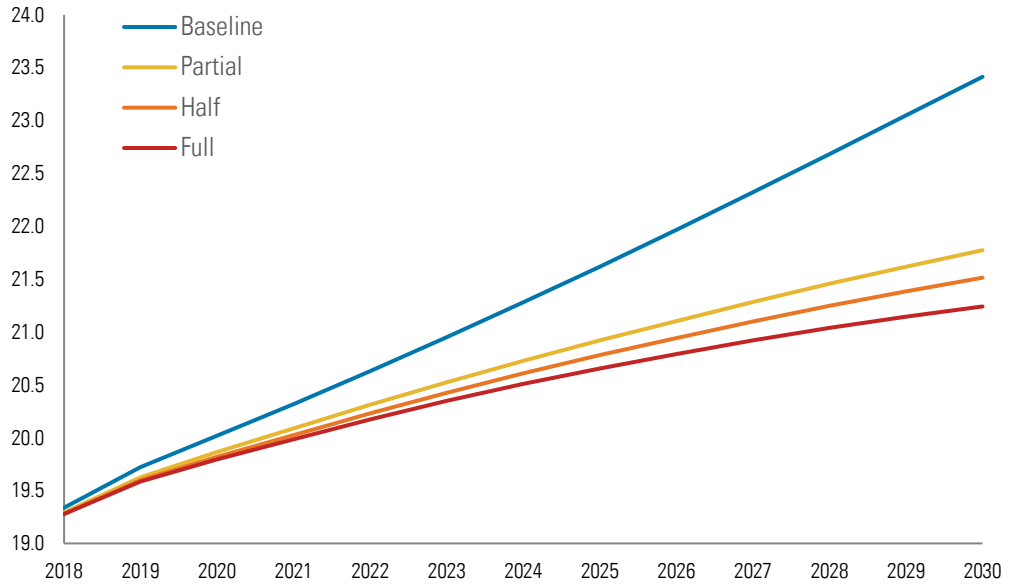
Percent deviation from baseline



Source: GTAP, RHG calculations.

Figure 8: Estimated U.S. GDP under Tariff Escalation Scenarios, 2018-2030

USD trillion



Source: GTAP, RHG calculations.

The cumulative impact on U.S. GDP builds over time. In the span of a decade, the U.S. economy racks up more than $1 trillion in losses across all tariff scenarios (Figure 8). By 2030, in the "partial" escalation scenario the hit will have reduced U.S. GDP by 7.0% over 13 years, while at "full" escalation the cumulative hit is 9.3%.

Impact on U.S. Productivity Growth

The contribution of ICT to economic growth is multifaceted. ICT drives productivity and economic growth through two main channels: through a direct increase in TFP contributed by ICT-producing sectors, and through capital deepening and labor productivity improvements in ICT-using sectors. TFP also reflects the gains from technological change, innovation, and efficiency improvements.

When capital deepening is reversed, productivity can take a hit. In our model results, TFP is presented as a cumulative growth rate over time; we also compute the average annual growth in TFP. In the baseline projection under the *status quo ante*, U.S. TFP grows 6.5% over the first five years, and 14.4% from 2018 to 2030. An estimation of TFP so far in the future doesn't mean much, as TFP is a residual of whatever labor and capital don't account for in GDP growth accounting. Even so, the average annual TFP growth needed to reach 6.5% cumulative growth in 2022 is around 1.4%.

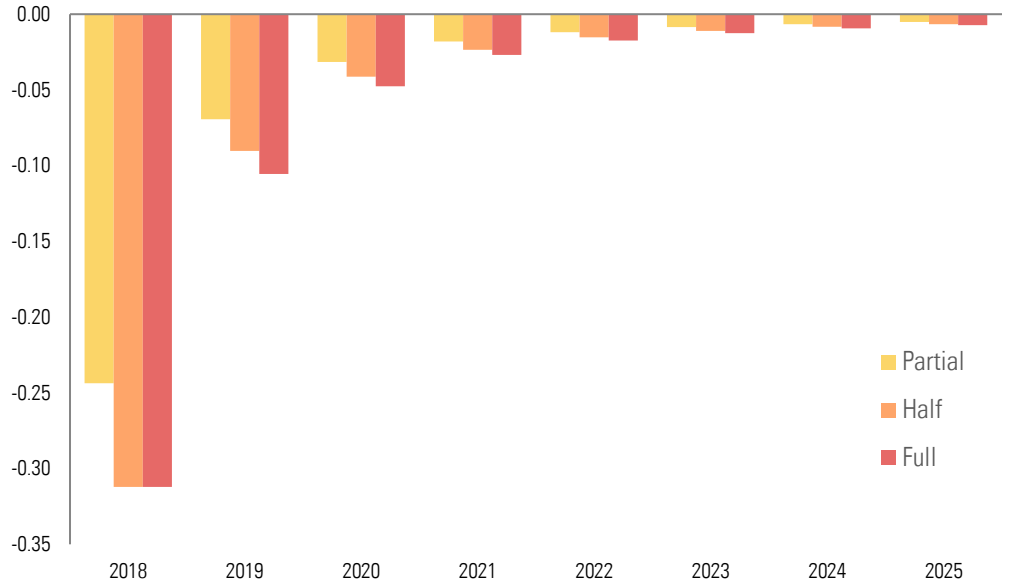
In all scenarios, bilateral tariff escalation reduces average annual TFP growth, but these effects subside over time as price effects of the initial policy shock wear off. Figure 9 shows how much the trade war would subtract—in percentage point terms—from U.S. real GDP growth, of which TFP growth is one of three contributors (with labor and capital). In 2018, the impact is projected to range from 0.24 to 0.31 percentage points but fades by 2025 in all scenarios.

Compared with our 2016 simulation of the impact on Chinese TFP growth from ICT "nativization," the TFP impact we project for the U.S. is smaller, primarily because the policy shock modeled is different. However, relative to actual U.S. TFP levels, the impact is significant. Average annual U.S. TFP grew by 1-1.5% in the 1990s to 2000s, faltered after the global financial crisis, and has since hovered in the 0.5%-1% range according to several measures.[24] But for the United States to sustain potential GDP growth rates around 2%, TFP growth at or above 1% is needed. ICT adoption was—and remains—critical for U.S. TFP growth, and is the area where the United States outperforms other economies. Tariffs diminish this key channel of TFP growth, especially when they target the ICT sector.

[24] E.g., U.S. Bureau of Labor Statistics; Federal Reserve Bank of St. Louis; Karim Foda, "The Productivity Slump: A Summary of the Evidence," Brookings Institution, August 2016. https://www.brookings.edu/wp-content/uploads/2016/08/productivity-evidence.pdf.

Figure 9: Reduction in Average Annual U.S. TFP Growth, 2018-2025

Percentage point deviation from baseline TFP growth



Source: GTAP, RHG calculations.

The TFP estimations presented here are a product of the model, which bases TFP changes on broad inefficiencies in the allocation of resources stemming from price changes. It does not capture some other TFP effects such as firm heterogeneity—meaning there are variations in firm quality and product scope—under which low-productivity firms protected from import competition by tariffs could drag down aggregate TFP. In addition, our model assumes perfect competition among firms, so we don't capture the possibility that increased protection leads to a decrease in competition among firms, which may reduce TFP further.

Labor productivity is another key metric for understanding how policy shocks affect employment, wages, and resource allocation in economic growth. The modeled scenarios result in a small U.S. job loss on net, primarily due to the way the model is calibrated. This is because the tariffs generate positive employment effects due to increased domestic production, while the higher imported input costs have slightly more negative employment effects due to reduced domestic production.

Consumer Welfare, or "Absorption"

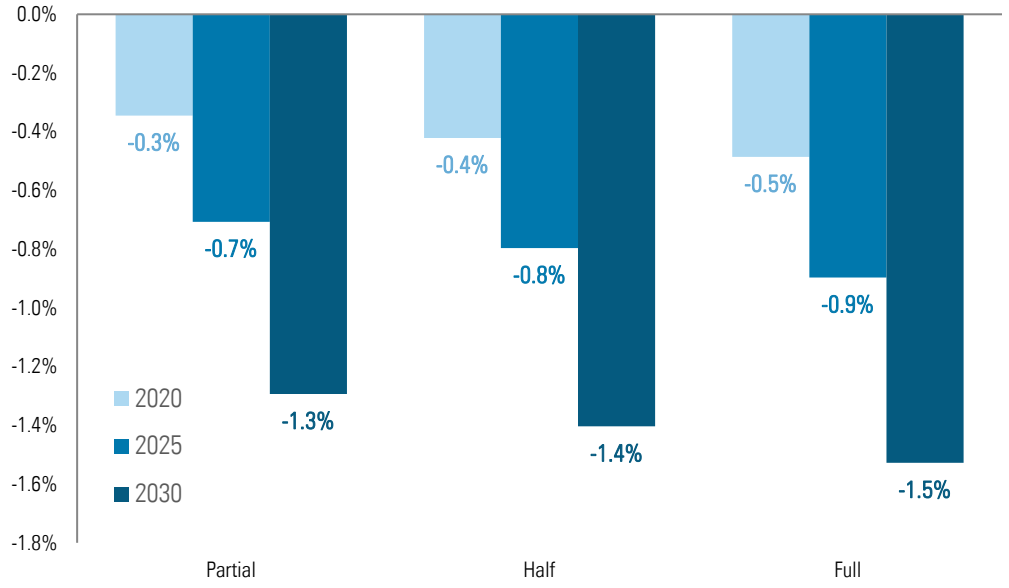
Tariffs raise both import and export prices, which lowers trade both ways. Lower imports mean U.S. residents consume more domestic products. The model results support this conclusion, as in all scenarios, domestic consumption of domestically-produced goods and services expands relative to the baseline. Lower U.S. imports also mean domestic production

faces less competition from foreign imports, which could shelter certain industries and lead to less innovation and thus less productivity.

The more important proxy for measuring welfare is "absorption," which encompasses aggregate demand for both intermediate inputs used by manufacturers and final goods and services used by consumers.[25] Because absorption reflects the consumption ability of the economy in aggregate, and not just how much the nation can send abroad to benefit consumers elsewhere, this is a better measure of aggregate welfare. As the below figure shows, in the "half" escalation scenario, the annual hit to gross consumption measured by absorption ranges from $81 billion in 2020 to $317.9 billion in 2030, or up to 1.4% lower than baseline projections.

Figure 10: Impact on Annual U.S. Gross Domestic Consumption ("Absorption"), 2020-2030

Percent deviation from baseline



Source: GTAP, RHG calculations.

Sectoral Impacts: U.S. ICT Goods and Services

Because we've chosen to model the impacts of a specific bilateral policy—i.e. U.S.-China tariffs—our results show a strong impact on both economies. The impact on ICT, and especially ICT merchandise, is significant, which reflects the importance of GSCs to this industry.

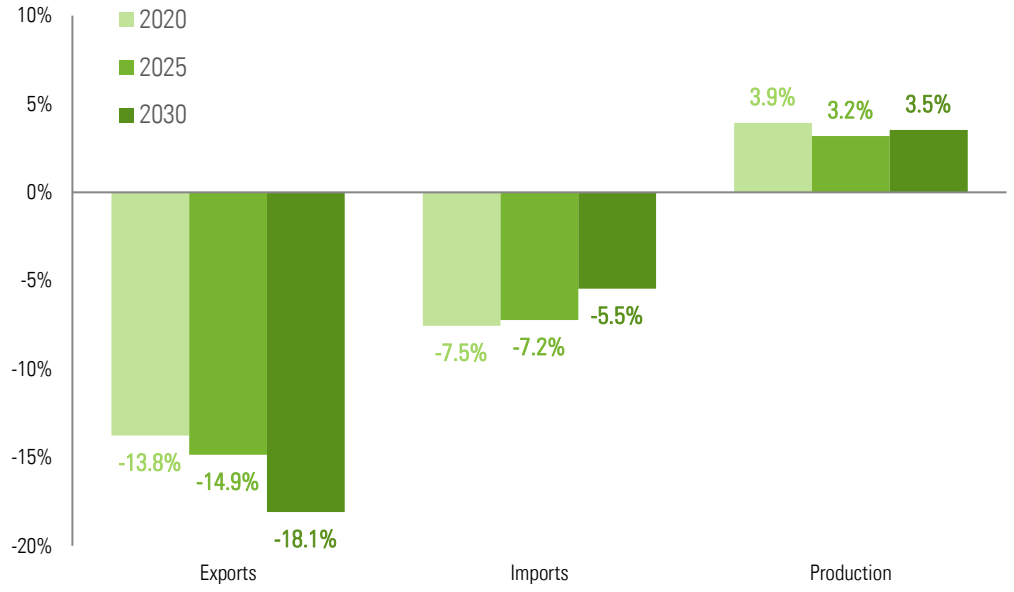
[25] United States International Trade Commission, "The Economic Effects of Significant U.S. Import Restraints," Seventh Update, 2011, pg. 7. https://www.usitc.gov/publications/332/pub4253.pdf.

ICT goods exports deviate far from baseline projections. In the "half" escalation scenario, which simulates tariff escalation beyond current 10% levels, U.S. ICT goods exports fall by $14 billion (-12.5%) in year one and $17.5 billion (-14.4%) five years later (Figure 11), adding to a cumulative loss of $79.3 billion total over the period. Because the U.S. ICT manufacturing sector is highly import-dependent, costlier inputs translate into lower imports and exports for the sector. In aggregate, U.S. ICT imports fall, and consumption of domestic ICT rises, resulting in a lower level of U.S. ICT goods exports.

Under all scenarios, U.S. ICT goods production increases marginally, ranging from 2.6% to 4.8% higher annually. This is largely because higher prices lead to reduced imports, so domestic production must rise to meet domestic demand. While a portion of domestic demand that was being serviced from abroad would consequently be serviced at home, a 3-4% rise in domestic ICT production per year does not indicate large-scale "onshoring" of U.S. ICT production from abroad.

Figure 11: Impact on U.S. ICT Goods in "Half" Escalation Scenario, 2020-2030

Percent deviation from baseline



Source: GTAP, RHG calculations.

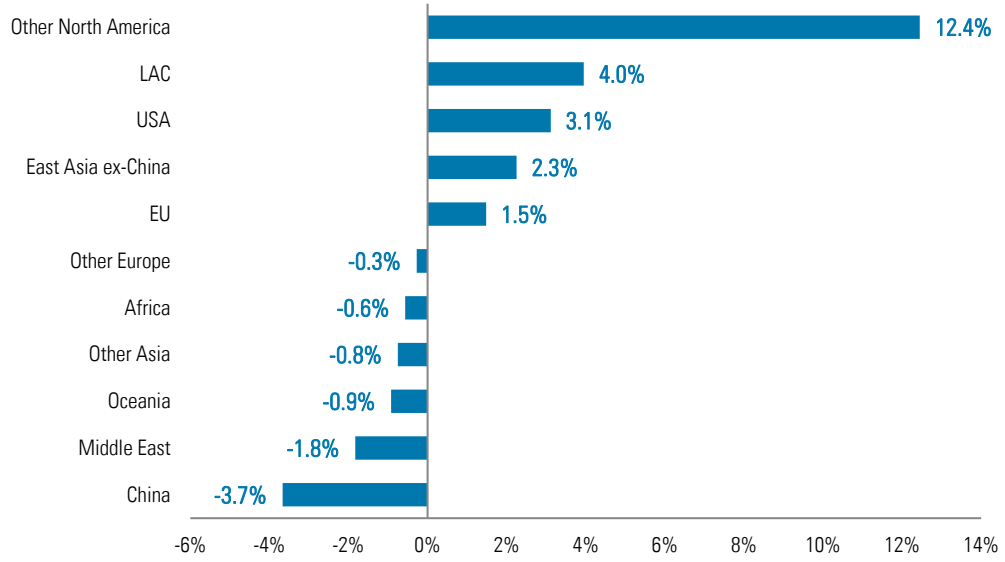
ICT production uses an extremely globalized production chain, and it's very expensive to change that given the strong ecosystem built in China. Computer and electronics manufacturing is among the top three export industries to GVCs for both the United States and China, while the United States is the top exporter of manufactures using Chinese inputs

through GVCs.[26] This suggests that, even if U.S. production were to shift out of China, some components would still have to be sourced from China indirectly, adding not just cost but complication to a highly segmented process.

The model results suggest that ICT merchandise supply chains would be redirected out of China and into North America and Latin America. As Figure 12 shows, China-based ICT manufacturing takes the biggest hit of all regions five years after the "partial" escalation scenario takes hold, under which U.S. tariffs on Chinese imports are concentrated in tech-sensitive products. Meanwhile Canada and Mexico would fill most of the gap left by China in ICT manufacturing, likely reflecting the lower tariff rates (and therefore trade costs) along the North American corridor under the 2017 projection of the world economy. Looking ahead, it is possible that free trade agreements currently under renegotiation, if passed, will reshape cost structures around North American supply chains. Likewise, U.S. tariffs on steel and aluminum imports from most trade partners, levied in 2018 and in effect at the time of writing, affect estimated trade diversion under different U.S.-China tariff escalation scenarios but were not considered in this model.

Figure 12: Impact on ICT Goods Production by Region under "Partial" Escalation Scenario Five Years Later*

Percent deviation from baseline



Source: GTAP, RHG calculations. *Based on GTAP database regional classifications, EU is EU 28; Middle East includes Saudi Arabia; Oceania includes Australia and New Zealand; LAC includes Argentina, Brazil, Central America, and Latin America; East Asia includes Japan and South Korea; Other North America includes Canada and Mexico; Other Europe includes Russia, Turkey, and the Balkan States; Other Asia includes Indonesia and India.

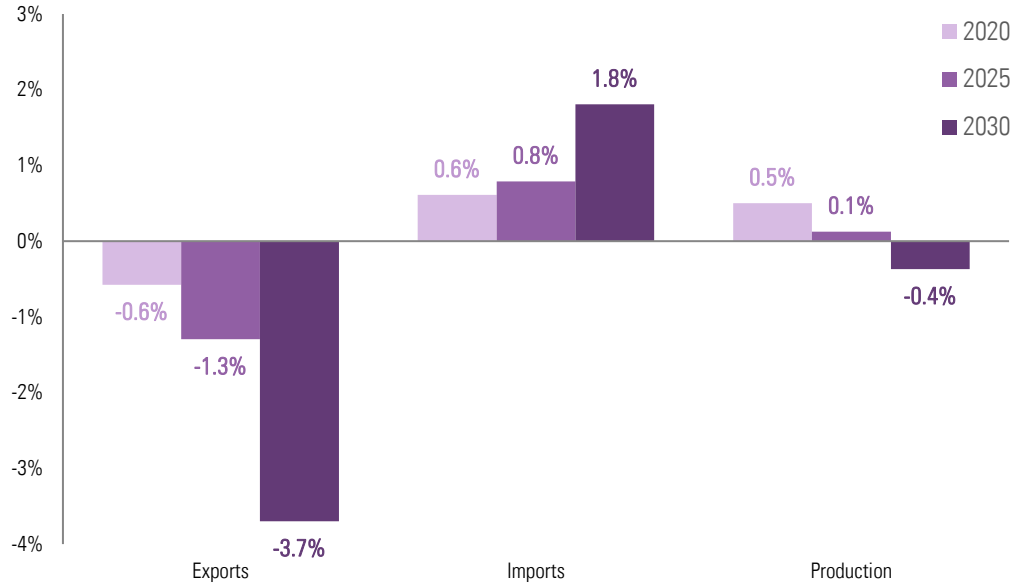
[26] World Trade Organization, "Trade in Value Added and Global Value Chains," United States and China country profiles (2011).

While East Asian countries experience a boost in domestic ICT merchandise production, other Asian countries see lower-than-baseline output. This reinforces a key point: diversion of production out of China doesn't necessarily mean production shifts to lower-cost developing Asian countries as is conventionally thought. A more detailed analysis within specific product segments is needed to accurately gauge impacts on established global supply chains.

The impact on the U.S. ICT services sector is more subdued—not surprising, given the goods trade policy shock being modeled—but intensifies over time. This implies that, while short-run costs are dominant in price-sensitive segments of the economy and subside over time, the long-run costs of a bilateral trade war are felt more strongly by the ICT services sector.

Figure I3: Impact on U.S. ICT Services in "Half" Escalation Scenario, 2020-2030

Percent deviation from baseline



Source: GTAP, RHG calculations.

Trade models are limited in their ability to capture the full impact on the services sector; moreover, data on services sector trends do not comprehensively reflect the myriad benefits consumers enjoy as a result of ICT and ICT-enabled services globalization.[27] Although services trade is not subject to direct import tariffs, it is indirectly affected by tariffs due to the critical role services play in facilitating all goods trade, and especially in highly fragmented supply chains including for ICT. The OECD's TiVA database shows that services sectors contribute 14%

[27] Services trade is more difficult to quantify accurately and consistently across economies than goods trade due to its intangibility and ability to be delivered via different modes. Services trade activities are also subject to rapid advances in technology, resulting in changing definitions and increasing scopes of services activities. Thus, barriers to services trade and potential gains from liberalization are difficult to quantify accurately. Andreas Lindner et al., "Trade in Goods and Services: Statistical Trends and Measurement Challenges," Organization for Economic Co-Operation and Development Statistics Brief No. 1, October 2001. https://www.oecd.org/trade/its/2539563.pdf.

of the value-added in U.S. ICT goods exports, 30% in all U.S. manufacturing exports, and more than 60% in all U.S. ICT industry (goods and services) exports.

Global Impacts

China and the United States—in that order—suffer the biggest hit to potential GDP growth across all tariff escalation scenarios. As the two biggest economies in the world, downgrades to Chinese and U.S. GDP lead to global growth that is $176.4 billion (0.2%) lower than projected in 2025 if all bilateral trade is taxed, and $151.4 billion lower if 25% tariffs on $260 in bilateral goods trade move ahead in the "half" escalation scenario.

Table 4: Impact on GDP by Region in 2025*

USD million; percent deviation from baseline

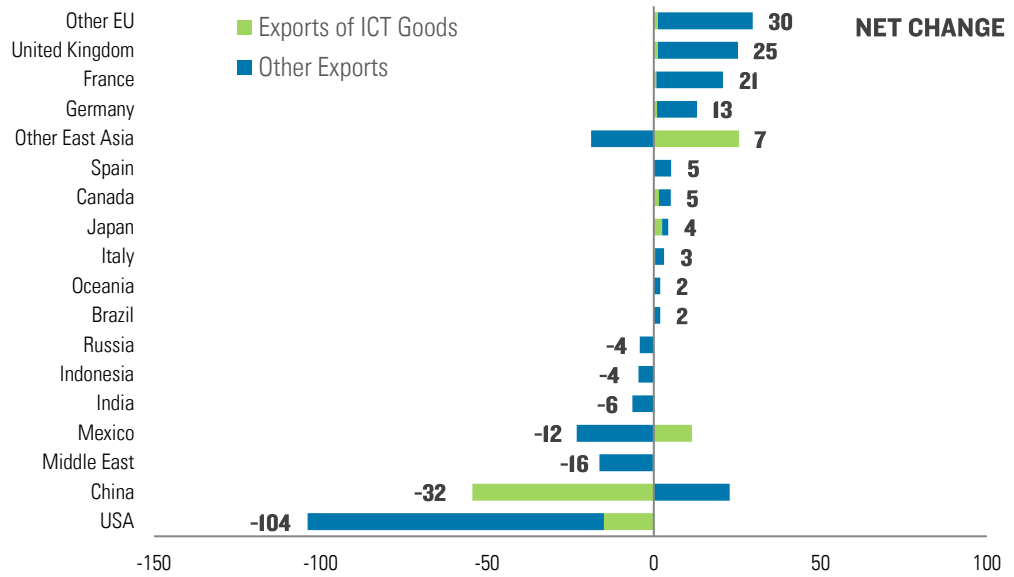
REGION	PARTIAL		HALF		FULL	
USA	-145,270	-0.7%	-165,590	-0.8%	-190,450	-0.9%
CHINA	-146,872	-0.8%	-171,669	-0.9%	-234,614	-1.2%
EU	13,179	0.1%	13,357	0.1%	25,741	0.1%
MIDDLE EAST	5,134	0.1%	5,439	0.1%	9,255	0.2%
AFRICA	11,790	0.4%	11,922	0.4%	14,258	0.4%
OCEANIA	1,686	0.1%	1,853	0.1%	3,428	0.2%
LAC	21,966	0.4%	24,192	0.5%	30,659	0.6%
EAST ASIA EX-CHINA	41,119	0.4%	42,136	0.4%	57,233	0.5%
OTHER NORTH AMERICA	45,178	1.4%	47,366	1.4%	58,484	1.8%
OTHER EUROPE	15,761	0.4%	15,833	0.4%	18,932	0.5%
OTHER ASIA	23,619	0.4%	23,771	0.4%	30,666	0.5%
WORLD TOTAL	-112,708	-0.1%	-151,389	-0.2%	-176,408	-0.2%

Source: GTAP model, RHG calculations. *Based on GTAP database regional classifications, EU is EU 28; Middle East includes Saudi Arabia; Oceania includes Australia and New Zealand; LAC includes Argentina, Brazil, Central America, and Latin America; East Asia includes Japan and South Korea; Other North America includes Canada and Mexico; Other Europe includes Russia, Turkey, and the Balkan States; Other Asia includes Indonesia and India.

Ironically, the U.S.-China trade war would benefit other countries and hurt the United States. The biggest beneficiaries from bilateral tariff escalation are Canada and Mexico, in GDP terms, alluding to the potential diversion of trade through those countries if U.S.-China trade breaks down. Figure 14 suggests that most ICT goods exports shift from the U.S. and China to Hong Kong and Taiwan ("Other East Asia" excludes Japan and South Korea), as well as Mexico and, to a lesser degree, Canada and Japan. Most diverted exports are not ICT merchandise, however, reflecting the impact of Chinese tariffs on U.S. chemicals, agriculture, energy, and vehicles and parts exports. Most of the loss in U.S. exports accrues to EU members, led by the U.K., France, and Germany.

Figure 14: Shifting Exports in Selected Regions under Half Escalation Scenario Two Years Later

USD billion deviation from baseline exports in 2019



Source: GTAP model, RHG calculations. Other EU is EU 28 excluding UK, France, Germany, Spain, Italy. Middle East excludes Saudi Arabia. Other East Asia excludes China, Japan, and South Korea.

These results are echoed by a 2019 study conducted by the United Nations Conference on Trade and Development (UNCTAD). A cross-sectoral comparison suggests the impact of tariffs on international trade patterns depends upon how easily U.S.-China trade can be substituted with products from other countries. While some bilateral trade is lost due to higher prices, or substituted by the domestic economy, the biggest impact is trade diversion. U.S. tariffs hit machinery and ICT equipment trade the most, while the main diversionary impact of Chinese tariffs is in chemicals, vegetable products, and automobiles.[28] In sum, tariffs make suppliers in the rest of the world more competitive relative to U.S. and Chinese firms.

Key Takeaways from the Model

The projected impacts on the U.S. economy are modest compared to the full ICT "nativization" scenario modeled in our 2016 study on the hit to China's welfare, but they are large in the context of U.S. growth. The impacts we observe would swamp the realized benefits of some of America's biggest modern trade and investment deals. The World Bank estimated that the original 12-member Transatlantic Trade Partnership, concluded in 2015, could have delivered

[28] United Nations Conference on Trade and Development, "Key Statistics and Trends in Trade Policy 2018: Trade Tensions, Implications for Developing Countries," UNCTAD/DITC/TAB/2019/1, February 2019, p. 3. https://unctad.org/en/PublicationsLibrary/ditctab2019d1_en.pdf.

an additional 0.6% of GDP to North American Free Trade Agreement (NAFTA) countries.[29] The Transatlantic Trade and Investment Partnership between the United States and the European Union was estimated to generate U.S. gains ranging from $69 billion to $131 billion.[30] Of course these are not apples-to-apples comparisons, and liberalization adds wealth in different ways than restrictiveness reduces it, but in broad terms the costs of a U.S.-China bilateral trade war would largely defeat the hard-won gains of trade and investment liberalization in other areas.

In our estimations, the conservative $45 billion hit to potential U.S. GDP in year one grows to $400 billion total in the first five years; within one decade, the U.S. economy stands to come up $1 trillion short of its baseline potential. Mild scenarios shave up to one-third of a percentage point in TFP from real GDP growth of 2-3%, threatening a key channel for transmission of the benefits of an open ICT sector to the economy.

In addition, the model indicates a significant degree of trade diversion. This is a testament to the current policy threat being a *bilateral* trade war in a *multilateral* global economy. Hits to production, trade, and investment accrue to the United States and China, while the rest of the world including Canada, Latin America, and East Asian countries reap benefits from trade diversion. While the U.S. and China see lower-than-potential growth, rest of the world GDP gains by more than $400 billion by 2030 in the "full" tariff escalation scenario. The diversionary effect is amplified in the ICT sector, which operates under liberalized ITA trade rules and thus presents less friction to trade diversion.

ASSESSING IMPACTS OUTSIDE THE MODEL: ICT EXPOSURE

Limitations of the Model

Modeling is not a precise exercise, and the results of our model only apply within the parameters of its assumptions. For example, the GTAP model applies assumptions about how easily economies can substitute goods and services with those from other countries after tariffs hit, and how firms behave under a given policy shock. (See Annex for more details about model methodology.)

We used a perfect competition model, which does not capture much heterogeneity at firm-level within a given industry. This may mean that our results are relatively conservative. When we account for imperfect competition and firm heterogeneity, the negative effects of higher tariffs would be higher than in the perfect competition model, because the reduced competition from high tariffs would reduce productivity and therefore result in greater losses to the economy.

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[29] World Bank, "Potential Macroeconomic Implications of the Trans-Pacific Partnership," *Global Economic Prospects*, January 2016, p. 219-255. http://pubdocs.worldbank.org/en/847071452034669879/Global-Economic-Prospects-January-2016-Implications-Trans-Pacific-Partnership-Agreement.pdf.

[30] Centre for Economic Policy Research, *Reducing Transatlantic Barriers to Trade and Investment: An Economic Assessment*, London, March 2013. http://trade.ec.europa.eu/doclib/docs/2013/march/tradoc_150737.pdf.

Another limitation is that, while the model does capture dynamic investment decisions—such as expected and actual changes in rates of return—and hence lower investment and lower future production capacity arising from these policies, it does not capture the investment *uncertainty* or the ensuing hit to investor confidence arising from these policies. That is, the negative effects created by changing risk perceptions and uncertainty generated by the policy shock beyond expectations around rates of return on investment fall outside the scope of the model. To that extent, our estimates can be considered conservative.

In the following section, we aim to address two key questions: first, how can we understand differential impacts on U.S. ICT and high-tech industries below the aggregate-level model analysis; and second, how might key policy shocks at work in the bilateral trade dispute outside the modeled tariff imposition impact U.S. industries and the economy?

Differential Exposure Across U.S. ICT Industries

The model results reinforce that, because both the U.S. and China are highly integrated into GSCs—and are the most integrated in ICT industries—they stand to lose the most in investment, trade, and welfare from the imposition of bilateral tariffs.

Beneath the aggregate results, the structure of globalized ICT supply chains suggests that the more a given industry relies on processing and assembly in China, the more it will be impacted by the tariffs. This is not just because U.S.-based manufacturers rely on lower-cost intermediate goods from China, or because U.S. consumers use final ICT goods assembled in and exported from China. Significant U.S. assets have been built out in China over the past two decades, and thus U.S. multinational enterprises (MNEs) including those with affiliates in China are also a key link in the bilateral supply chain. As a result, U.S. tariffs concentrated in ICT goods will punish not just Chinese exporters, but also U.S. suppliers based in China.

From firm-level data on U.S. MNE activities by industry and affiliate country, we can approximate which ICT-linked trade flows with China directly involve trade with U.S. affiliates in China. The table below suggests more than 11% of U.S. communication equipment exports—a category which includes mobile phones and switching and routing apparatus—to China are purchased by U.S. affiliates in China. On the import side, 2.9% of U.S. machinery imports, 5.3% of U.S. semiconductor and other electronic component imports, and 4.2% of navigational and other instruments from China are shipped by U.S. foreign affiliates in China. These are top among the ICT manufacturing subsectors hit hardest by U.S. tariffs. The share of U.S. imports from China originating from all foreign-invested enterprises (FIEs) is likely much higher.[31]

[31] Mary E. Lovely and Yang Liang, "Trump Tariffs Primarily Hit Multinational Supply Chains, Harm US Technology Competitiveness," Peterson Institute of International Economics, Policy Brief 18-2, May 2018. https://piie.com/system/files/documents/pb18-12.pdf.

Table 5: Estimated Share of U.S. Goods Trade with China via U.S. Foreign Affiliates There*

Percent

INDUSTRY CATEGORY		IMPORTS	EXPORTS
MACHINERY		2.9%	8.0%
	Industrial machinery	0.3%	0.6%
	Other non-agricultural machinery	--	5.9%
COMPUTERS AND ELECTRONIC PRODUCTS		2.1%	11.6%
	Communications equipment	--	11.2%
	Semiconductors and other electronic components	5.3%	9.6%
	Navigational, measuring, and other instruments	4.2%	--
	Computers and electronics ex-semiconductors	1.7%	13.0%
ELECTRICAL EQUIPMENT, APPLIANCES, AND COMPONENTS		1.9%	6.9%

Source: U.S. Bureau of Economic Analysis, U.S. Census Bureau. Some data are not available to protect company information.
*Figures are approximated using 2016 U.S.-China NAICS goods trade data, and BEA 2016 data on activities of U.S. MNEs.

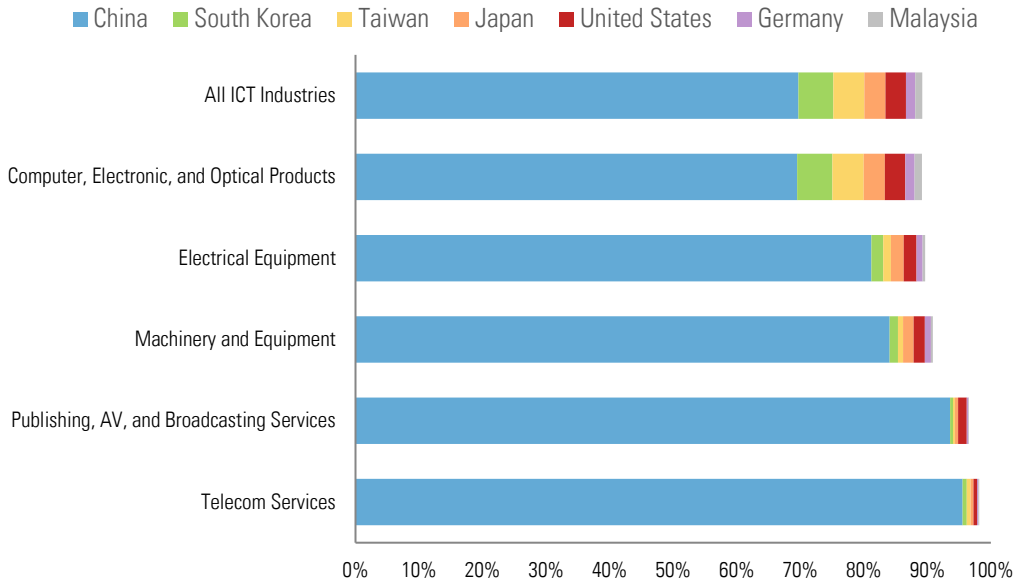
A more granular product or subindustry level assessment is limited by data availability and the capability of macro models to capture meaningful microeconomic effects. One of the best comprehensive, consistent sources of data on global value flows in knowledge- and information-intensive industries is the OECD's TiVA database. Our analysis of TiVA data suggests that U.S. tariffs hurt U.S. manufacturers in global supply chains in which China and the United States have an outsized presence—and relatively more in segments where they contribute high value.

Focusing on one-way bilateral trade flow, Figure 15 considers how U.S. tariffs on ICT goods and services imports from China could directly impact different ICT value chains. The United States is among the top four sources of value in China's ICT-related exports to the United States, with critical East Asian trade partners rounding out the other top positions. In all ICT industries, 3.2% of the value-added in China's exports to the United States actually originates in the United States. The subindustry with the most American value-added is computer, electronic, and optical products, at 3.2%. In addition, 2% of Chinese electrical equipment and 1.8% of its machinery and equipment exports to the U.S. contain value-added by American firms.

As of 2015, China domestically produced 70% of the value-added in its total ICT goods and services exports to the United States. Whereas domestic value contributed about the same percent of China's ICT merchandise exports, its ICT services exports to the United States rely almost entirely upon domestic value-added. The United States is the biggest foreign source of value in China's ICT services exports to the U.S., though the share is microscopic compared with domestic value-added.

Figure 15: Top Sources of Value-Added in China's ICT-Related Exports to the U.S., 2015*

Share of total



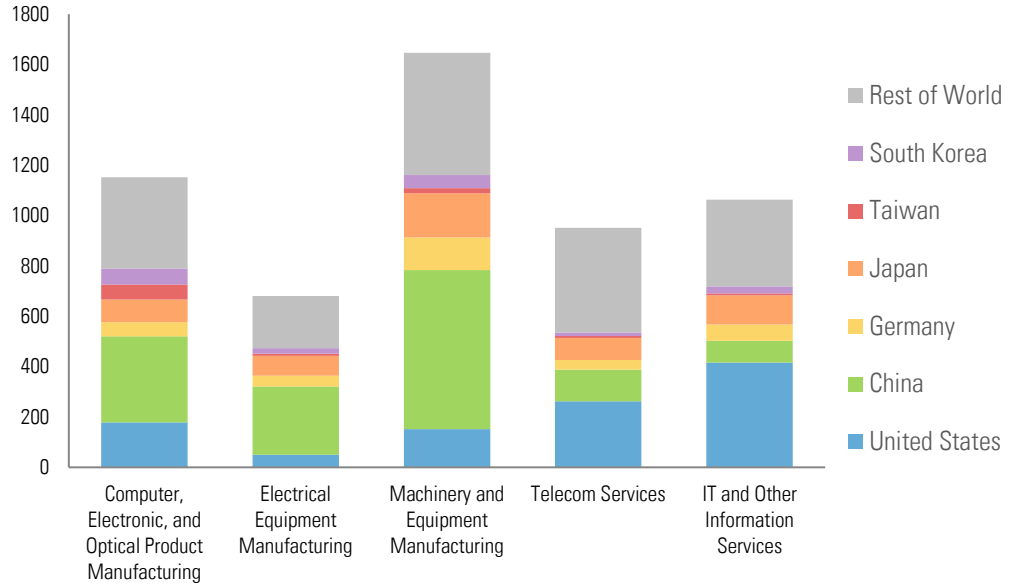
Source: OECD Trade in Value-Added database. Last updated December 2018. In its definition of ICT industries, the OECD includes Computers, Electronics, and Optical Products Manufacturing; Publishing, Audio-Visual, and Broadcasting Activities; Telecommunications Services; and IT and Other Information Services.[32] The remaining subsectors are included here for relevance to the ICT industry.

The implications of "trade war" should also consider the indirect impacts on different ICT industries outside just the application of tariffs on bilateral flows. In terms of global final demand for ICT goods and services, the United States faces high exposure in the computer, electronic, and optical products segment within ICT merchandise, but is even more integrated in GVCs for ICT services. The figure below shows that IT and other information services is one of the main ICT segments where potential American value is most at risk.

[32] According to the OCED's classification, "The aggregate of information industries here includes ISIC rev. 4 Division 26 (Manufacture of computer, electronic and optical products) and Section J (Information and communication), which in turn consists of Divisions 58-60 (Publishing and broadcasting industries), 61 (Telecommunications) and 62-63 (Computer programming, and Information service activities). Hence information industries here encompass ICT industries (Divisions 26, 61 and 62-63, plus group 58.2, software publishing), with the exception of Trade and repair activities, as well as Media and content industries (included in Divisions 58-60 and in the Group 63.9)."

Figure 16: Value-Added by Country in Final Demand by ICT-Related Industry, 2015*

USD billion



Source: OECD Trade in Value-Added database. Last updated December 2018. In its definition of ICT industries, the OECD includes Computers, Electronics, and Optical Products Manufacturing; Publishing, Audio-Visual, and Broadcasting Activities; Telecommunications Services; and IT and Other Information Services. The remaining subsectors are included here for relevance to the ICT industry.

Understanding the impacts on specific ICT segments as well as other critical and emerging industries in which U.S. innovation leads global competitors warrants deeper examination but is hindered by the lack of disaggregated data for quantifying the impact. Other studies broadly reaffirm the above analysis—that is, policy measures like tariffs that raise the costs of key productivity- and innovation-enhancing capital goods and services central to ICT segments can harm U.S. competitiveness in ICT and tech-intensive industries and beyond. A 2018 report from the Peterson Institute for International Economics finds that 80% of trade targeted by the $200 billion tariff list falls within sectors designated by the U.S. Department of Commerce as patent-intensive, suggesting a tax on knowledge flows.[33]

A 2018 analysis from the Information Technology & Innovation Foundation finds that users of cloud computing technology, including U.S. business, governments, and consumers, would bear the biggest negative effects U.S. tariffs as higher costs are passed down, compelling some businesses to choose to invest less in productivity-enhancing technology in new industries like

[33] Mary E. Lovely and Yang Liang, "Trump Tariffs Primarily Hit Multinational Supply Chains, Harm US Technology Competitiveness," Peterson Institute of International Economics, Policy Brief 18-2, May 2018. https://piie.com/system/files/documents/pb18-12.pdf.

cloud computing.[34] Cloud computing service providers hit with higher costs from tariffs face higher operational costs, which risks reducing revenues that fund investment in R&D and new capacity and facilities.

U.S. tariffs on printed circuit assemblies—an important electronics component in many products—and the connected devices that use them would have a substantial negative impact on American consumers. A study published by the Consumer Technology Association found that 10% to 25% U.S. tariffs on consumer-facing connected devices such as wireless headsets, portable speakers, and wi-fi routers could reduce their consumption by 6%-12% and raise prices for consumers from $1.6 billion to $3.2 billion.[35] Imposing 10% to 25% tariffs on integrated circuit imports would cost the U.S. economy $110 million to $612 million annually.[36]

Outside the direct effects of tariffs, the "trade war" imposes costs in other ways. One key negative effect is that of uncertainty, which is best reflected in financial market volatility and impacts on investment. While our model does capture changes in investments based on average firm behavior, it does not capture the added uncertainty that has already played out in U.S. and Chinese stock markets, currency dynamics, and investment decisions. A 2018 World Bank study simulated the impact of a decline in investor confidence (i.e., a 0.5 percentage point drop in investment-to-GDP), and found that under 25% tariffs on all two-way trade, uncertainty reduces global income by 1.7% ($1.4 trillion).[37] Ultimately, if firms perceive tariffs as temporary, they may choose not to incur the significant costs of relocating production processes; tariffs perceived as permanent may alter investment decisions and have a longer lasting effect, even if tariffs are removed.[38]

In addition, the global economic policy environment has changed rapidly in 2018. Many new policy initiatives, if implemented, could reshape global trade patterns and complicate analysis of welfare implications of these policy choices. In the United States, some of the policies with the most potential for disruption include renegotiation of NAFTA, tariffs on steel and aluminum, and potentially auto tariffs. In addition, the United Kingdom's exit from the European Union is one of the biggest looming shocks to global economic flows. The impacts of policies outside U.S.-China "trade war" are not assessed in this report.

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[34] Stephen J. Ezell and Caleb Foote, "Why Tariffs on Chinese ICT Imports Threaten U.S. Cloud-Computing Leadership," Information Technology & Innovation Foundation, September 2018. http://www2.itif.org/2018-china-cloud-tariffs.pdf.

[35] Trade Partnership Worldwide LLC, "Estimated Impacts of Proposed Tariffs on Imports from China: Connected Devices and Printed Circuit Assemblies," Consumer Technology Association, August 6, 2018. https://prod1.cta.tech/CTA/media/policyImages/Estimated-Impacts-of-Proposed-Tariffs-on-Imports-from-China_-Printed-Circuit-Assemblies-and-Wireless-Telecommunications-Accessories.pdf.

[36] Trade Partnership Worldwide LLC, "Estimated Impacts of Proposed Tariffs on Imports from China: Connected Devices and Printed Circuit Assemblies," Consumer Technology Association, August 6, 2018. https://prod1.cta.tech/CTA/media/policyImages/Estimated-Impacts-of-Proposed-Tariffs-on-Imports-from-China_-Printed-Circuit-Assemblies-and-Wireless-Telecommunications-Accessories.pdf.

[37] Caroline Freund et al., "Impacts on Global Trade and Income of Current Trade Disputes," *MTI Practice Notes* No. 2, World Bank Group, July 2018, p. 4. http://documents.worldbank.org/curated/en/685941532023153019/pdf/128644-REVISED-MTI-Practice-Note-2-11-12.pdf.

[38] United Nations Conference on Trade and Development, "Key Statistics and Trends in Trade Policy 2018: Trade Tensions, Implications for Developing Countries," UNCTAD/DITC/TAB/2019/1, February 2019, p. 5-6. https://unctad.org/en/PublicationsLibrary/ditctab2019d1_en.pdf.

IMPLICATIONS FOR U.S. COMPETITIVENESS

Current global economic and policy conditions are novel, and our quantitative analysis can only go so far in divining future competitiveness in this new world. In ICT in particular, deglobalization policies have gained momentum worldwide. Our model compares a baseline world economy with one subject to an adverse trade policy shock, but just how adverse the policy outlook can be is a moving target. The pace of bilateral trade conflict escalation demonstrates that goods trade and the ICT sector are not the end of the story. Rather than being a tail risk, tariffs are a precursor of further divergence, barring a significant course correction in China.

In this section, we provide a qualitative assessment of the most important policy shifts—outside the terms being negotiated with China—relevant to the outlook for U.S. competitiveness. These policies are still being developed, but to sharpen the contours of the outlook, we examine their implications for U.S. competitiveness.

Tighter Security Reviews for Foreign Investment

Views about tradeoffs between open markets and investment on the one hand and the risks entailed in foreign acquisitions on the other are in flux. Stricter screening for high-tech sectors is in fashion not just in the United States but in many advanced economies.

The U.S. Foreign Investment Risk Review Modernization Act (FIRRMA) was enacted in August 2018 and represents the most significant transformation of the Committee on Foreign Investment in the United States (CFIUS) in decades. FIRRMA expands CFIUS jurisdiction to cover certain investments below the traditional 10% stake threshold involving "critical technologies," including those designated under U.S. export control regulations and those classified as "emerging and foundational technologies" under the Export Control Reform Act (ECRA) of 2018 (full definitions still pending).[39] FIRRMA likewise expands CFIUS coverage over investments in "critical infrastructure" and in companies with access to sensitive personal data.

While final rules are still pending, interim rules effected through a pilot program in November 2018 related to FIRRMA's critical technologies provisions expanded the scope of transactions subject to national security review in select industries.[40] ICT and other technology-intensive sectors are notably impacted—six of the 27 pilot program industries are classified as ICT

[39] On November 19, 2018, the Department of Commerce's Bureau of Industry and Security published an advance notice of proposed rulemaking ("ANPRM") seeking public comment on criteria for identifying emerging technologies that are essential to U.S. national security under the ECRA. BIS is expected to issue a separate ANPRM regarding criteria for identifying foundational technologies that may be important to U.S. national security. U.S. Department of Treasury, "FAQs on FIRRMA Critical Technology Pilot Program," October 10, 2018. https://home.treasury.gov/system/files/291/-Pilot-Program-FAQs.pdf.

[40] For full list of industries, see "Determination and Temporary Provisions Pertaining to a Pilot Program to Review Certain Transactions Involving Foreign Persons and Critical Technologies," *83 Federal Register 197* (October 11, 2018), p. 513222. https://home.treasury.gov/system/files/206/FR-2018-22182_1786904.pdf.

manufacturing industries, while others range from sectors using technologies with explicit military applications to sectors with broader dual-use applications. Additional forthcoming implementing regulations, including final definitions of emerging and foundational technologies under ECRA, could further increase restrictions on investment in industries using critical technologies.

FIRRMA created new headwinds for Chinese ICT investment in the U.S. against a broader background of uncertainty surrounding bilateral trade negotiations, tariff escalation and export controls that was already weighing on investor sentiment and reshaping investment flows into the United States. These and other forces drove completed Chinese FDI in the U.S. down 84% to just $4.8 billion in 2018—the lowest level since 2011.[41] End-2018 data show the preliminary impacts of tighter U.S. investment screening, including a downturn in Chinese high-tech and venture capital investments. These dynamics portend to a continued negative impact on Chinese ICT and technology-intensive investment in the United States in 2019.

Wider Use of Export Controls to Prevent Technology Transfer

Export controls have also been flagged as warranting expansion to ensure national security. The ECRA, passed in August 2018, aims to enhance U.S. export controls to address concerns about the transfer of critical technologies to certain end uses and users, particularly in China. The ECRA establishes a formal interagency process to identify "emerging and foundational technologies" that are "essential to the U.S. national security" and not covered by FIRRMA or existing export controls. This will likely present an additional hit on American ICT economic interaction with the world, with a corresponding impact on U.S. welfare.

The U.S. Department of Commerce's Bureau of Industry and Security (BIS) has begun to step up controls on exports to China. In August 2018 BIS added 44 Chinese entities, including several large state-owned enterprises to the list of entities to which exports, reexports, and transfers of controlled items are prohibited.[42] Some entities, such as the China Electronic Technology Group Corporation, were listed due to their alleged illicit acquisition of U.S. technologies for military end-uses in China.[43] The BIS imposed strict controls on these entities, meaning export of *any* item subject to the Export Administration Regulations—including readily available hardware, software, and technology—is subject to additional licensing requirements.[44]

Congress has not yet defined the technologies or industries to be covered by the new export control legislation, but preliminary proposals suggest the ICT sector will be heavily impacted.

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[41] Thilo Hanemann, Cassie Gao, and Adam Lysenko, "Chinese Investment in the US: 2018 Recap," Rhodium Group, January 9, 2019.
[42] "Addition of Certain Entities; and Modification of Entry on the Entity List," 83 Federal Register 148 (August 1, 2018), p. 37423-37432. https://www.govinfo.gov/content/pkg/FR-2018-08-01/pdf/2018-16474.pdf.
[43] Lori Scheetz, "BIS Adds 44 Chinese Entities and Institutions to its Entity List," USA Trade Blog, August 6, 2018. https://www.ustradeblog.com/2018/08/bis-adds-44-chinese-entities-and-institutions-to-its-entity-list/.
[44] Hogan Lovells, "BIS Expands Entity List with Addition of 44 Chinese Parties," Lexology, August 2, 2018. https://www.lexology.com/library/detail.aspx?g=ee7413ab-83fb-4410-a833-1f1e8ede4346.

On November 19, 2018, the BIS published an advance notice of proposed rulemaking to start the process of identifying "emerging" technologies that should be subject to restrictions on transfer to foreign persons, especially those located in China.[45] The list covers 14 categories of emerging technologies, including biotechnology, artificial intelligence and machine learning, microprocessor technology, advanced computing technology, robotics, and others.[46]

Export controls can impose significant burdens on the economy in several ways.[47] For one, unilateral export controls disadvantage the U.S. economy by costing American firms sales opportunities or market share, thereby hurting U.S. competitiveness. Second, there is a risk that controls could be overextended to cover exports that have no real national security basis for protection. Third, the U.S. export control system is broad and complex, leading to delays that can disadvantage American firms in going to global markets early.[48]

We cannot predict how expanded export controls on U.S. technologies will impact the U.S. ICT landscape, nor can we say whether new limitations on high-tech exports across U.S. borders will create security benefits that can justify the potential loss of economic welfare. These questions warrant in-depth assessments on a case-by-case basis. However, we can argue that policy intervention resulting in non-market barriers to trade, investment, and knowledge flows create negative externalities for U.S. firms. New controls on the technology and IP exports from the U.S. risk making America less attractive as a hub for high-tech investment, R&D collaboration, and innovation.

Resurgence of Industrial Policies in Advanced Economies

Some advanced economies are revisiting old debates about the role for industrial policy, ostensibly to defend and promote innovation and competitiveness, especially in emerging technologies. Countering China's industrial policies is a standard justification for this. It may sound ironic that advanced economies are contemplating state interventions to confront the problems of China's state interventions, but it is no longer impolite to raise the topic.

Trump-era U.S. policy shows this drift. New tariffs, quotas, and voluntary export restraint demands have been employed to favor labor-intensive industry over others. President Trump created the Office of Manufacturing and Trade Policy, a White House advisory council for industrial policy, in May 2017. The Industrial Policy office at the Department of Defense

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[45] Bureau of Industry and Security, Commerce, "Review of Controls for Certain Emerging Technologies", 15 CFR 744, *Federal Register*, November 19, 2018. https://www.federalregister.gov/documents/2018/11/19/2018-25221/review-of-controls-for-certain-emerging-technologies.
[46] Bureau of Industry and Security, Commerce, "Review of Controls for Certain Emerging Technologies", 15 CFR 744, *Federal Register*, November 19, 2018. https://www.federalregister.gov/documents/2018/11/19/2018-25221/review-of-controls-for-certain-emerging-technologies.
[47] Institute of Medicine, National Academy of Sciences, and National Academy of Engineering, "The Impact of Export Controls on U.S. Industry," *Finding Common Ground: U.S. Export Controls in a Changed Global Environment*, Washington, DC: The National Academies Press, 1991, p. 18. https://www.nap.edu/read/1617/chapter/5.
[48] Institute of Medicine, National Academy of Sciences, and National Academy of Engineering, "The Impact of Export Controls on U.S. Industry," *Finding Common Ground: U.S. Export Controls in a Changed Global Environment*, Washington, DC: The National Academies Press, 1991, p. 18-20. https://www.nap.edu/read/1617/chapter/5.

advises on foreign investment in the U.S., manufacturing capabilities, and budget matters related to the defense industrial base.[49]

Increasing pressure on the U.S. administration to use industrial policy more to counter China predates Trump's election, as exemplified by U.S. semiconductor industrial policy. In November 2016, then-Commerce Secretary Penny Pritzker warned that Beijing was subsidizing Chinese firms to expand market share domestically and globally in integrated circuits, while restricting access to China's domestic market.[50] President Obama's Council of Advisors on Science and Technology followed in January 2017 with a report asserting the need to respond to Chinese non-market industrial policies designed to shift competitive dynamics in the semiconductor industry in favor of Chinese production and companies.[51]

This is not just an American impulse. The European Commission and other OECD members have advocated innovation industry-oriented policies over the past decade.[52] Measures being considered by several advanced economies in the ICT space focus on subsidizing R&D spending through tax credits or government investments. Recent industrial policy proposals in Germany, for example, explore various themes: setting targets for increasing industrial sector contributions to the economy; stronger government investment in R&D and innovative technologies to level the playing field with Chinese companies; and merging major companies to become "national champions."[53]

Industrial policies that distort competitive market processes will add to the negative impact from U.S. tariff escalation on the trade outlook, though the effects of industrial policy are difficult to measure and vary by policy instrument. In general, government intervention in allocating resources can encourage rent-seeking behavior and lower economic efficiency, thereby reducing economic welfare.

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[49] "About Industrial Policy." U.S. Department of Defense website. https://www.businessdefense.gov/About/.

[50] David Lawder, "U.S. Commerce Chief Warns against China Semiconductor Investment Binge," Reuters, November 3, 2016. https://www.reuters.com/article/us-usa-china-trade-semiconductors/u-s-commerce-chief-warns-against-china-semiconductor-investment-binge-idUSKBN12Y0EG.

[51] 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

[52] E.g., European Policy Centre, "Towards a New Industrial Policy for Europe," EPC Issue Paper No. 78, November 2014. http://www.epc.eu/documents/uploads/pub_4995_towards_a_new_industrial_policy_for_europe.pdf; OECD, "Industrial Policy for a Sustainable Growth Path," p. 13. https://www.oecd.org/eco/Industrial-Policy-for-a-sustainable-growth-path.pdf

[53] "German Minister Defends Controversial Industrial Strategy," Deutsche Welle, February 3, 2019. https://www.dw.com/en/german-minister-defends-controversial-industrial-strategy/a-47344440; "Partner and Systemic Competitor –How Do We Deal with China's State-Controlled Economy?" BDI, January 2019. https://english.bdi.eu/media/publications/#/publication/news/china-partner-and-systemic-competitor; "EU Antitrust Policy under Fire after Siemens-Alstom Deal Blocked," Reuters, February 6, 2019. https://uk.reuters.com/article/us-alstom-m-a-siemens-eu/eu-antitrust-policy-under-fire-after-siemens-alstom-deal-blocked-idUKKCN1PV12L.

III. CONCLUSION: PUTTING IT ALL TOGETHER

This report explores the immediate and long-term economic impacts threatened by U.S. trade policy actions on the U.S., China and other economies. Our projections are based on existing and proposed actions stemming from the ICT-oriented Section 301 case undertaken by the Trump Administration. Measures already taken are huge: as of February 2019, approximately 57% of the value of gross US-China bilateral goods trade is subject to tariffs levied by both sides in this confrontation. By using a combination of economic modeling and qualitative assessment, we offer conclusions on what can be said with computational rigor, and what can be said with careful qualitative reasoning, on the impact of these policy developments on the ICT sector.

From the quantitative modeling section of this report, we draw four principal findings:

- Escalation of bilateral tariffs results in lower GDP, lower employment, lower investment, and lower trade flows for the United States.

- The annual hit to U.S. GDP ranges from $45 billion to $60 billion in year one and grows to a range of $89 billion to $125 billion five years later. Cumulatively, the U.S. economy stands to come up $1 trillion short of its baseline potential within ten years of tariff implementation in all scenarios.

- In ICT manufacturing, U.S. ICT goods exports will be 14% to 20% lower than they would be otherwise within five years, with most of the reduced activity being diverted to East Asia (ex-China) and Mexico. As a result of higher prices, U.S. ICT goods imports would fall by 9% to 10%. Domestic ICT production rises marginally by 3-4% annually in all scenarios to meet the gap in domestic demand left by reduced imports.

- Global growth will be $151.4 billion (0.2%) lower than baseline projection in 2025 if 10% U.S. tariffs effective as of February 2019 rise to 25%. China and the United States experience the biggest reductions in GDP, while Canada and Mexico see big increases.

A number of the conclusions we reach in this report draw from analysis that goes beyond economic modelling.

- Nearly half (49%, or $113 billion) of the U.S. imports from China subject to new tariffs are *intermediate goods*, which comprise semi-finished goods used as inputs in the production of other products. This is a flag that reminds us to consider the follow-on impact of tariffs on U.S. competitiveness.

- The United States is the single biggest source of value-added in global ICT services value chains, and China is the biggest source in ICT manufacturing. This heavy presence in fragmented ICT value chains means high costs from a global disruption.

- U.S. tariff escalation hurts American and other foreign enterprises. More than 11% of U.S. communication equipment exports to China are purchased by U.S. affiliates in China. Nearly 3% of U.S. machinery imports, 5.3% of U.S. semiconductor and related device imports, and 4.2% of navigational and other instruments from China are shipped by U.S. foreign affiliates in China.

- At least 3.2% of the value-added in U.S. ICT imports from China is round-tripping product that originates in the United States. The segment containing the most American value-added is computer, electronic, and optical products.

These conclusions explain why advanced nations traditionally conduct a thorough economic impact assessment before locking in the threat of such a massive package of changes to economic policy. The tremendous momentum behind the present array of threats against trade with China is due in large part to the overlapping national security logic behind this campaign. While the goals are often couched in terms of economic competition fairness, the public discourse in Washington and abroad has turned more on theories of national security, geostrategic rivalry, and the danger of not protecting the innovative "ecosystem" that is the wellspring of American dynamism—including in military capabilities. If this were just debated in terms of consumer welfare, the economic models would tell us whether Americans are better off without access to products made in China. If there is far more at stake, then that is not the most important question in terms of American interests.

It is our view in this report that a clearer understanding of the traditional economic welfare effects of proposed trade policy action is essential, even if—or perhaps especially if—larger questions of national security and competition are at issue. Operating without the benefit of better information is not a boon to action, but an invitation to mistakes. We have through straightforward analysis substantiated four important points that arise from putting these pieces together:

- That the cost to American welfare from even modest ICT-deglobalizing U.S. trade policy scenarios is sufficiently high to merit comparison shopping for cheaper ways to achieve our goals, especially in many areas of trade which do not present real national security concerns;

- That impacts of trade policy actions already at an advanced stage are not well understood, and the real implications have not been subject to sufficient public debate;

- That the forces shaping the ICT sector in America go far beyond trade policy, and are already being altered by those forces even while we debate trade action;

- And finally, that the increased transaction costs imposed by tariffs, the reduced economies of scale and scope caused by cordoning off U.S. innovation from activity in China, and the reintroduction of political risk into the calculus of firms and individuals will have profound impacts on U.S. innovation and competitiveness which cannot be predicted. Concern for national security does not necessarily mean protection and U.S. industrial policy are the right way forward.

ANNEX: MODEL METHODOLOGY

AN OVERVIEW OF THE MODEL

The GTAP (Global Trade Analysis Project) model, a global computable general equilibrium (CGE) model, has been used extensively for policy impact analysis across the world since the early 1990s by economists from the European Commission, The World Bank, and government agencies, universities and research institutes in countries like Australia, the United States, and India.

This is a multi-country, multi-sector general equilibrium model. The WTO states that the purpose of the CGE simulations is to determine the effects of a change in trade policy on the endogenous variables of the model—prices, production, consumption, exports, imports and welfare.[54] The simulation represents what the economy would look like if the policy change or shock had occurred. The difference between the values of the endogenous variables in the baseline and the simulation represents the effect of the policy change. All the policy simulations as well as results reported in this report, as in other major models of this type, may be thought of as occurring in one shot over a time period needed for equilibrium to be achieved.

Similarly, Gilbert (2013) writes that the idea behind CGE is to program a large-scale mathematical system representing the global economy and to combine that theoretical system with a benchmark set of real-world data representing the status quo. The equilibrium is then perturbed to generate insights into the direction and magnitude of the economic effects of policy intervention and/or other changes in the economic system.

The model assumes perfect competition, constant returns to scale and profit and utility maximizing behavior of firms and household respectively. Hertel (1997) provides detailed information about the structure and overview of GTAP model. GTAP combines economic theory and empirical data to account for all trade flow interactions among industries, consumers, and countries globally while simultaneously ensuring theoretical as well as accounting consistency.

GTAP is a publicly funded project based on Center for Global Trade Analysis, Purdue University, USA. The key features of a standard GTAP model are:

- All sectors of the economy are accounted for;
- All global regions are modeled, with the level of aggregation chosen by the user;

[54] WTO (2012), "A Practical Guide to Trade Policy Analysis", published by United Nation and World Trade Organisation.

- The model assumes perfect competition in all markets with price adjustments to ensure that all markets clear simultaneously;

- A regional household collects all the income in its region and spends it over three expenditure types: private household (consumer), government, and savings, over a Cobb-Douglas utility function;

- A representative firm maximizes profits in nested constant elasticity of substitution (CES) functions in a perfectly competitive market for each industry/sector in each region and pays income to the regional household for utilizing the endowment commodities (i.e., land, labor, capital, and natural resources);

- Bilateral trade as well as transport margins are computed across all commodities and regions;

- In an open economy, firms also export the tradable commodities and import the intermediate inputs from the rest of the world;

- The model follows the Armington assumption to account for product heterogeneity for outputs produced in different regions. This means there is imperfect substitution between domestic and imported goods.

    - Substitutability depends on the elasticity of substitution between imported and domestic goods, as well as on the initial share of the imported goods in total domestic use of the aggregated good;

    - The Armington assumption provides an effective framework for studying international trade policies and has been widely adapted across general equilibrium trade models.

- All money must be spent, all spending must be earned, and subsidies must be covered by taxes or borrowing;

- Market clearing is assumed—this means total value of output is equal to total value of domestic consumption and exports;

- Firms, private households and the government have different demand for imports;

- Imports must equal exports, by commodity and trade route;

- Global saving is equal to global investment;

- There are recursive dynamics for determining investment in the model to capture annual effect of policies.

DATABASE

The GTAP Data Base is a multi-country multi-sector dataset, which captures the input-output linkages between sectors and trade linkages between countries and regions across the world, while also taking into account several policies governing production, consumption, and trade. This is a unique dataset that collates data from various international sources, while reconciling their differences and imposing various constraints that result in a globally balanced dataset. It uses a state-of-the-art methodology that continues to be evolved and enriched with inputs from leading policy modelers and analysts across the world. This group forms the GTAP Advisory Board.

Our study uses the GTAP 9 Data Base, the latest version, which has 140 regions and 57 sectors, with a latest reference year of 2011.The simulated scenarios are reported in 2017 USD value or percent deviation from baseline.

Sources for the GTAP Data Base include UN COMTRADE (merchandise trade), World Bank (macro-economic data), ITC MacMAP (tariff data), IEA (energy data), IMF (services trade data), FAO (agricultural IO data), OECD (agricultural production and domestic support data), WTO (export subsidies data) and several national and international agencies that publish Input-Output tables of countries. Elasticity parameters also come with this dataset, and some of them are econometrically estimated while others are calibrated to tune the model for behavior consistent with theoretical predictions.

Running simulations on the fully disaggregated data with 140 regions and 57 sectors is attractive, but not feasible in practice, due to extremely resource-intensive processes required to solve such huge simulations. Standard practice is to create a custom aggregation specific to the problem at hand. We keep the 57 sectors but focus on G20 countries for the regional aggregation.

Another important aspect to consider before conducting the simulations is to understand the big picture implied by the data. Given the enormous amount of work involved in assembling the dataset as well as the feedback period from the Board, GTAP Data Base is publicly released only once in every 3-4 years. Hence the source datasets used in developing GTAP get more frequently updated than GTAP itself. This may result in inconsistencies in several macroeconomic numbers relative to updated or revised information.

To control for these revisions, we employ the historical data for 2017 from World Bank and IMF datasets to revise the numbers in GTAP Data Base. This is accomplished with a program called *GTAPAdjust*. This employs an Entropy Optimization (EOP) approach to target all the

macro variables, while not making substantial changes in the data otherwise. Entropy measures are created to measure the distance between the macro dataset and GTAP Data Base, and they are minimized in the optimization procedure. Everything else in the dataset adjusts in a proportional/scaled way compared to the original; for example, we target total exports while bilateral exports follow the same pattern and destination shares as in the raw GTAP Data Base. We also develop a *status quo scenario* from 2018 to 2030, based on macro predictions from the UN and IIASA.

LIMITATIONS AND CAVEATS OF THE MODEL

Modeling is not a precise exercise, and the outcomes we compute only apply within the parameters of assumptions and limitations of the model. For example, the GTAP model applies assumptions about how easily economies can substitute goods and services with those from other countries after tariffs hit, and how firms behave under a given policy shock. In addition, while we measure the effect of trade policy relative to the computed baseline, this is not a forecasting model—the model uses projections developed within the GTAP database to construct baseline scenarios—so we cannot confirm the statistical accuracy or precision of these baseline predictions, as is typical for this approach.

Bilateral tariffs in our model were approximated based on actual tariff lines and rates listed by U.S. and Chinese authorities at the standard level of Harmonized System (HS) classification (8-digits). These goods were summed into aggregate sectors in the model database, and tariff rates were applied based on a given product's share within an aggregate sector. Within the GTAP model's 57 sectors, ICT goods includes manufactures of office, accounting, and computing machinery and manufactures of radio, television, and communication equipment and apparatus (codes 30 and 32 in ISIC Rev. 3); ICT services includes post and telecommunications (code 64 in ISIC Rev. 3).

Given time constraints, we used a perfect competition model, which does not capture much heterogeneity at firm-level within a given industry. This may mean that our results are relatively conservative. When we account for imperfect competition and firm heterogeneity, the negative effects of higher tariffs would be higher than in the perfect competition model, because the reduced competition from high tariffs would reduce productivity and hence resulting in greater losses to the economy.

Another limitation is that, while the model does capture investment dynamics—such as expected and actual changes in rates of return, etc.—and hence lower investment and lower future production capacity arising from these policies, it does not have the capacity to explicitly and endogenously capture the investment uncertainty arising from these policies. That is, the negative effects created by changing risk perceptions and uncertainty generated by the policy shock beyond the expectations and actualities in rates of return fall outside the scope of the model. To that extent, our estimates can be considered conservative.

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