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The US–China Relations and the Impact of the US–China Trade War: Global Value Chains Analyses

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April 2022

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Keywords: The US–China relation, the US–China trade war, global value chain, trade in value added; multinational enterprise

JEL classification: F13, F15, F62, D57

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Abstract

This study investigates the US–China relations and examines the impact of the US–China trade war on the global economy through the lens of global value chains (GVCs). We begin by reviewing the history of US–China relations in GVCs from three perspectives: cooperation, competition, and conflict. Using trade in value-added as a metric, we show that the world economy is transitioning from "hyperglobalization" to "slowbalization," with the corresponding US–China interdependence varying across different value-added creation processes in GVCs. With a focus on the ICT sector, one of the most contentious battlegrounds in the US–China trade war, our GVC-based network analysis investigates the changing power and influential area of both the United States and China in GVCs, considering multinationals' activities. Furthermore, GVC-based computable general equilibrium analysis reveals that the impact of a trade war on an economy is highly dependent on its position and degree of participation in GVCs. The essence of the US–China trade war, the contradictory stances behind the trade war, and the outlook of the US–China relations in GVCs are discussed.

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*: Section 2 and 6 in this paper are mainly based on Meng (2020)'s previous work "The US-China relations in the post COVID-19 era: A global value chain perspective" published in the Review of Tokyo Foundation for Policy Research in Japanese (see https://www.tkfd.or.jp/research/detail.php?id=3499 and https://www.tkfd.or.jp/research/detail.php?id=3501).

1. Introduction

The trade conflicts between the United States and China that began in 2018 have attracted the world's attention, and their vicious tit-for-tat treatments, including imposing higher tariffs on each other, are also referred to as the "US–China trade war." The impact of the US–China trade war is unlike any previous trade conflict, such as the US–Japan trade friction in the 1980s, which focused on a specific industry or product (Irwin 1996). This is mainly because the current trade war between the United States and China involves all stakeholders (countries or regions, industries, and firms) that have been deeply involved in global value chains (GVCs) upstream and downstream through both trade in intermediate goods and services and cross-border investment. In this sense, the US–China trade war will have long-term, large-scale, and far-reaching consequences. Even more worrisome is that this trade war, triggered by the rapid deterioration of US–China relations, will be a double shock, compounded by the subsequent coronavirus disease 2019 (COVID-19) pandemic, thereby bringing additional uncertainty and risk to GVCs. With this as a turning point, the nature and structure of GVCs, as well as the international rule formation in the 21st century, will change dramatically.

This paper aims to use GVC-based analysis tools to explain the US–China relations and investigate the impact of the US–China trade war on the global economy, thus providing relevant policy implications for better international GVC governance.

What exactly are GVC analyses? Economic globalization can be viewed from various perspectives, such as trade, investment, immigration, information sharing, and technology transfer. There are various analytical foci, but none of them allow us to grasp the overall picture of economic globalization, which can result in the so-called "blind men and an elephant"-type situation. By contrast, GVC analyses are concerned with "the flow of value" or the value embodied in the flows of goods and services, people, money, and information in production and consumption networks. Thus, they treat economic globalization as a global game of value creation, transfer, and distribution among countries (Inomata 2019). Therefore, GVC analyses can provide useful and systematic insight when discussing US–China relations and investigating the impact of the US–China trade war.

GVC analyses are primarily concerned with the "value" game; as concrete examples of "value," the terms "value-added" and "income" in economics can be considered. Today, manufacturing products, ranging from smartphones to aircraft, do not necessitate a single country or firm to complete the entire process from design to parts manufacturing, assembly, sales, and after-sales service (in many cases, this is impossible). Instead, they are made in GVCs by various countries and firms. Consequently, the "made in" label, which is common on manufactured goods and identifies them with a specific economy, has become an archaic symbol of a bygone era, as most manufactured goods are now "Made in the World" (WTO-IDE 2011, Antràs and Chor 2021). In other words, different countries and firms use their comparative advantages to compete and cooperate with one another, gaining value through participation

in GVCs. However, the value gains from GVC participation are not automatic. When each country participates in this GVC game, value acquisition is heavily influenced by the country's level of participation in GVCs and its position in GVCs, such as being located at the low-end or high-end (Meng et al. 2020). This perspective posits that the essence of the US–China trade war is a fierce competition between these two countries for national interests, centered on areas of value capture and control in GVCs, which is now gradually culminating in a new type of "cold war." More importantly, the impact of the US–China trade war extends to all countries involved in GVCs, particularly East Asian and ASEAN countries and regions that are closely linked to the United States and China in GVCs.

The international input–output (IO) model and the computable general equilibrium (CGE) model are used in this study, which takes macroeconomic and quantitative approaches to analyzing US–China relations in GVCs, the essence of the US–China trade war from the perspective of GVCs, and its economic impacts on the global economy. This paper is organized as follows. To begin, in Section 1, we discuss the historical relations between the United States and China from the perspective of GVCs to explain the context of the US–China trade war. In Section 2, economic statistics, including the indicator of trade in value-added, are used to provide an overview of GVC trends. To accomplish this, we present an accounting system capable of identifying GVC activities in a country's value-added creation process. Moreover, we explain the changes in GVC activities, with a focus on China's value-added exports to the United States and its other major trading partners, including the EU, East Asia, and ASEAN. In Section 3, we conduct a network analysis that explicitly considers the activities of multinational enterprises (MNEs) to explain the US–China relations along GVCs. We focus on the ICT industry, one of the most representative examples of the GVC phenomenon and one of the fiercest battlegrounds of the US–China trade war. The network analysis used is from a topological standpoint, which can elucidate the interdependence between the United States and China, and among all participants in the corresponding GVC. Section 4 treats the US–China trade war as an external shock and presents the results of simulation analysis using the CGE model. Our analytical targets include not only the United States and China, which are direct participants in the trade war, but also the economies participating in GVCs with close ties to these two countries. Finally, in Section 5, based on the previous four sections' analysis, we discuss the future relationship between the United States and China in GVCs and the outlook for GVC governance.

2. Historical relations between the United States and China in GVCs

Over the last two decades, US–China relations in GVCs have progressed through three stages (Meng 2020). Stage 1 covers the period roughly from China's World Trade Organization (WTO) accession in 2001 to the global financial crisis in 2008. During this time, US–China relations shifted toward "Cooperation > Competition." This was supported by the complementarity of each country's

comparative advantages in GVCs. The United States possessed substantial capital, GVC governance-related knowledge, intellectual property, and technology. Moreover, its MNEs are brimming with an ambition to maximize global profits. Furthermore, 70% of US GDP was spent on household consumption, implying that the United States preferred consumption over savings, resulting in the world's highest purchasing power market. Meanwhile, China, despite appearing to have an endless supply of cheap labor, faced a scarcity of capital, technology, and GVC governance expertise. Furthermore, threats to the ruling administration owing to unemployment-related pressures were a major source of concern. As a result of the so-called three-fold pressure of education, medical, and housing expenses, China tended to prioritize savings overconsumption, resulting in a much higher savings rate than the United States.

In the real economy, this type of complementary relationship allows the United States to establish a close relationship with China. This was reflected in GVC development-related trends at the start of the 21st century. This was symbolized by the words "designed in California, assembled in China" carved into the back of iPhones. The single MNE Foxconn Technology Group (headquartered in New Taipei City), an original equipment manufacturer for Apple, resulted in nearly a million domestic hires in China (Ngai and Chan 2012). Furthermore, China became the world's largest holder of US national bonds in 2008, even in the financial economy on the other side of the real economy, with its USD-denominated currency reserves. Hence, both countries enjoyed a "honeymoon" period through GVCs, thanks to a "Chimerica"-like symbiotic relationship (an economic community comprised of the United States and China) (Ferguson 2008) that supported China's oversaving and the United States' overconsumption. In exchange for opening its markets to the United States, China received job opportunities, capital, technology, and access to overseas markets. Simultaneously, a massive number of cheaper China-made products satisfied the United States' voracious appetite for consumption, whereas US-owned MNEs continued to reap vast profits through expansion into China, making significant progress toward total GVC dominance. Both countries achieved what they wanted.

The events of the 2008 global financial crisis demonstrated that the "Chimerica" honeymoon period did not last long. The hollowing out of industry as a result of increased overseas outsourcing of operations and foreign direct investment (FDI) has been particularly painful for US blue-collar workers who have been forced to compete with robots at home and Chinese workers abroad, particularly in the manufacturing industry (Autor et al. 2013; Pierce and Schott 2016). With employment opportunities for these blue-collar workers dwindling and real wages stagnant for many years (Meng et al. 2020), the focus of discussion increasingly shifted to the massive number of US jobs being snatched away by "Made in China" products, not only in the mass media but also in the academic and political worlds (Meng and Hakozaki 2019).

Nevertheless, China was dissatisfied with the limited gain from GVCs in terms of value-added (e.g., the United States received approximately 60% of the value-added generated by iPhone production,

whereas China received less than 4% share (Xing and Detert 2010)). Moreover, given the competition with other developing countries due to rising domestic labor costs, China has pushed toward a rapid industry upgrading and innovation promotion strategy (Lin and Wang 2016; Cheng et al. 2020). Consequently, the United States and China experienced overlapping control or influence in GVCs, which gradually led to friction. One example is the rise of Huawei, a major Chinese telecommunications company. The Obama administration was wary of China's rise and enacted policies such as "rebalancing to Asia" and the Trans-Pacific Partnership (TPP). In GVCs, US–China relations gradually shifted from "Cooperation > Competition" to "Competition > Cooperation."

China has repeatedly stated that US–China relations in the GVC are not a zero-sum game but rather a win–win situation (Sangwon 2015). Meanwhile, the United States does not appear to have been made aware of this emphasis on reconciliation. At the absolute level, both countries benefit from GVCs; nevertheless, the expansion of China's control or influence can only mean a reduction in those controlled by the United States. To quote political scientist Kenneth Waltz (2001), "the closer the competition, the more strongly states seek relative gains rather than absolute ones." Consequently, the United States, a superpower brimming with self-confidence and wit, began to grow impatient and began to regard China as a genuine threat.

The fact that China is regarded as a threat is undoubtedly due to the latter's corresponding level of power. The country's rise in GVCs has not been limited to specific fields, but it is all-encompassing and simultaneously occurring. According to the 2019 edition of the "Fortune Global 500," a global company ranking, 119 Chinese companies (including those from Hong Kong) made the list, just two fewer than the United States (Fortune Global 2019). Donald Trump, believing that the United States had been exploited by China up to that point, was elected President with the slogan "Make America Great Again," plunging into the US–China trade war. The two countries' relations have progressed to the third stage, "Conflict > Competition > Cooperation." How US–China relations will evolve during the Biden administration remains unclear. However, to "outcompete China" more effectively, the US government is betting on a comprehensive renewal of supply chains combined with a quick shift in government thinking that recalibrates economic policy toward economic competitors, particularly China (The White House 2022).

3. Trend of GVCs based on economic statistics

3.1 Share of trade in value-added in the global GDP

For the trend of GVCs, trade statistics is one of the most important information sources. However, traditional trade statistics, such as the amount of imports and exports from customs records, are in gross terms, which may result in the so-called double calculation problem due to the trade of intermediate

goods and services that may cross multiple borders multiple times. For example, in 2009, China exported US$2,023 million worth of iPhones to the United States in gross terms, but in value-added terms (net term), China's value-added exports to the United States through iPhone trade were only US$73 million (Xing and Detert 2010). In other words, China's value-added share of the iPhone value chain is only 3.6% (73 / 2,023). This is because when the iPhone was assembled in China, intermediate goods from various countries and regions were used. For example, the following are included: an iPhone 3G with an export unit price of US$179, a flash memory of US$24 provided by Toshiba (Japan), a display module of US$19, a touch panel of US$16, an application processor provided by Samsung (South Korea) of US$23, parts such as basebands and camera modules provided by Infineon Technology (Germany) of US$30, and Bluetooth provided by Broadcom (USA) of US$6. Thus, it is unsuitable for measuring value in the GVC game using exports from trade statistics in gross terms because we cannot determine how much value-added a country gained by participating in GVC. To avoid such double calculation issues, the concept of trade in value-added based on IO models has become widely used in recent years (Johnson and Noguera 2012, Koopman et al. 2014). It quantifies how much of one country's added value is ultimately absorbed by the final demand of another country via complex international production networks. In other words, it can be defined as one country's domestic value-added embodied in exports that ultimately satisfy another country's final demand.

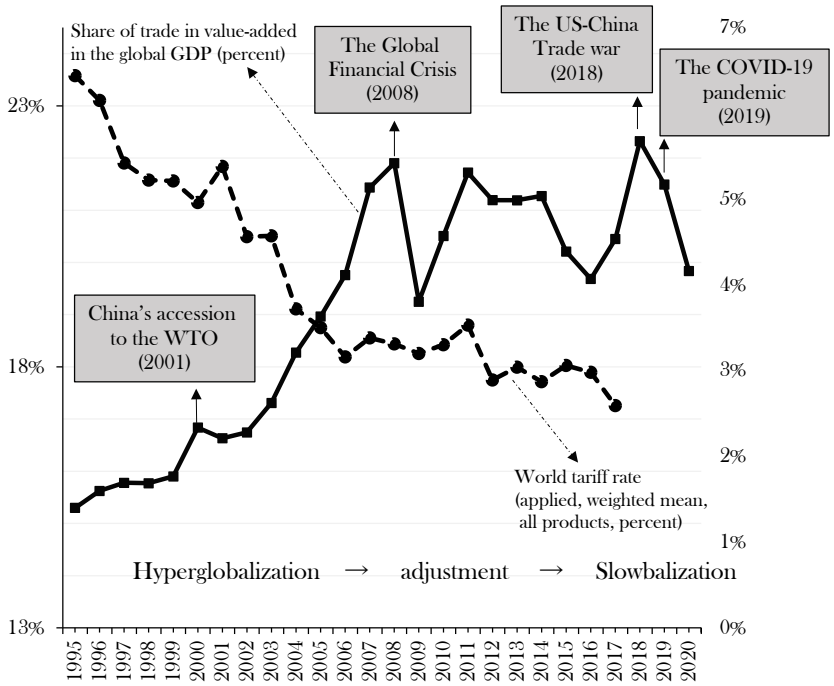

Figure 1. Share of trade in value-added in the global GDP

Data source: ADB MRIO tables (https://mrio.adbx.online/) and World Bank Indicator (https://data.worldbank.org/indicator/TM.TAX.MRCH.WM.AR.ZS)

Figure 1 depicts the ratio of trade in value-added to world GDP (left axis), that is, the percentage of world GDP created through international trade, using the concept of trade in value-added to time-series multiregional IO (MRIO) data from 1995 to 2020 compiled by the Asian Development Bank. Clearly, this ratio increased rapidly from 14.8% to 21.4% between 1995 and 2008, indicating the emergence of the so-called "Hyperglobalization" era. Behind this, the following are viewed as important factors: China's accession to the WTO, the reduction of international transportation and communication costs due to the development and global diffusion of technology and innovation, the continuous decline in tariff (e.g., see the world tariff rate shown on the right axis of Figure 1) and nontariff barriers due to FTAs, EPAs, regional trade liberalization, and more and easier cross-border capital movement (e.g., FDI). Nevertheless, following the global financial crisis of 2008, the contribution of trade in value-added to global GDP declined significantly, although it recovered to a level close to that before the crisis in 2011 but declined again in 2016. It was on a recovery trend again around the year 2018, but it plummeted due to the US–China trade war that occurred in 2018 and the COVID-19 pandemic that began in 2019. The world economy has entered an era of the so-called "slowbalization." These changes appear to be the result of at least three factors. First, as a result of trade agreements, the space for further reductions in tariff and nontariff barriers has shrunk (ADB 2021). Second, the rise of trade protectionism has become a hindrance to ongoing economic globalization, resulting from the hollowing out of the domestic industry in the overseas expansion of MNEs of developed countries to developing ones (Meng et al. 2020). Third, with the rapid industrialization of some emerging countries, especially China, more complex intermediate goods domestically can be procured rather than importing them from the world market, resulting in a decline in the trade in value-added to global GDP ratio. The slowbalization of the world economy from the GVC perspective as a macrotrend (Figure 1) could be interpreted as a sign of a deadlock or a necessary adjustment and regression of hyperglobalization gone too far.

3.2 Measuring GVC activities in value-added terms

We follow Wang et al. (2017) and Xiao (2019) in decomposing a country's GDP creation process via international trade into three routes to investigate GVC trends at the bilateral level, with a focus on the United States and China. There are three types of trade: traditional trade, simple GVC trade, and complex GVC trade. The production of domestic value-added embodied in final product exports is referred to as value-added creation through traditional trade. This is the domestic value-added used to meet foreign final demand without involving any cross-border production activities. Domestic value-added crosses a national border for consumption in this case, making it remarkably similar to the traditional "Ricardian" type trade, that is, "French wine in exchange for England English cloth" (Borin and Mancini 2015). Value-added creation through GVC trade refers to the production of domestic

value-added that is embodied in intermediate goods and services exports, which can be further subdivided into simple and complex GVC trade. The former refers to the domestic value-added absorbed by the trading partner country without the need for additional border crossings. Domestic value-added crosses a national border only once, with no third-country indirect exports or re-export activities involved. The latter refers to domestic value-added absorbed by another country whose factor contents cross borders at least twice. Production sharing occurs between home and foreign countries through intermediate trade, with multiple cross-border transactions. China, for example, exports metal products to Japan, which are then used to manufacture car parts, which are then imported by Mexican automakers to assemble cars for sale to US consumers. When Japan is replaced by Mexico or the United States, and Mexico by Japan or the United States, but Japan and Mexico are not replaced by the United States at the same time, the example still reflects the complex GVC trade.

3.3 US-China trade in value-added via GVC trade

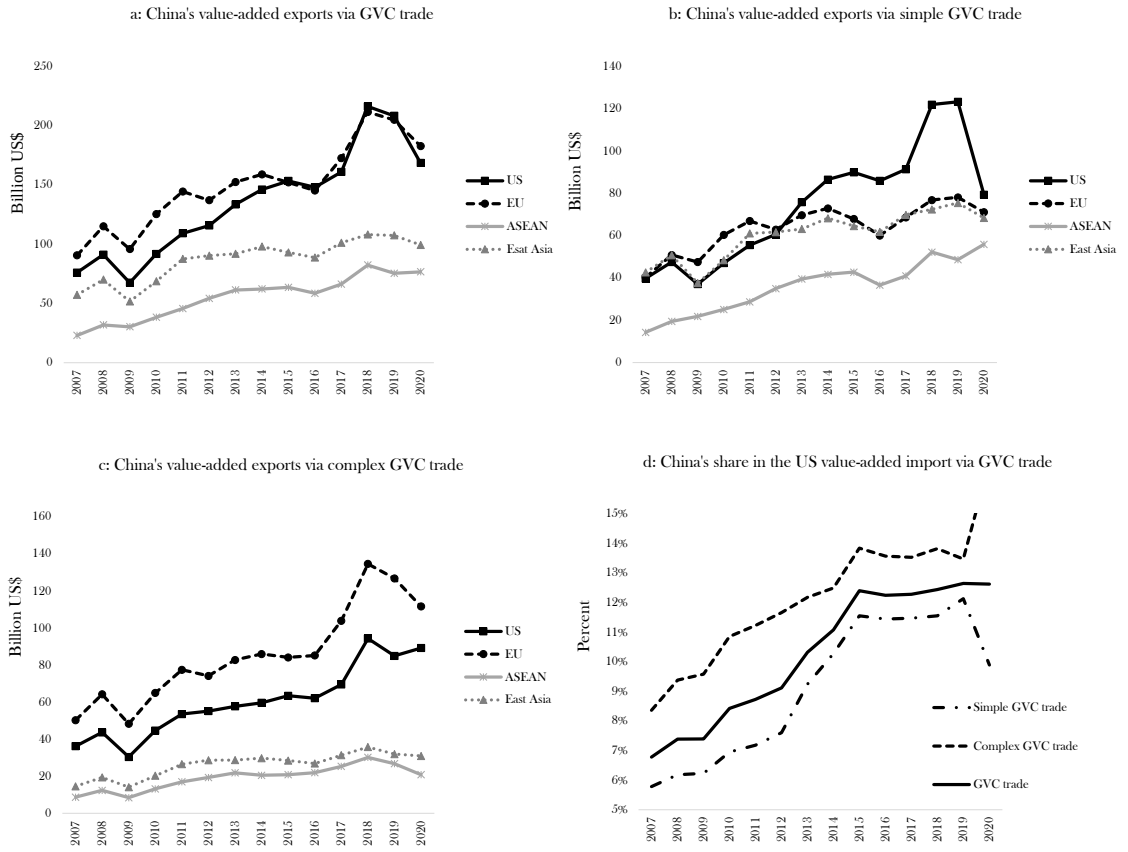

Figure 2. China's value-added exports via GVCs.

Data source: ADB MRIO tables

We could investigate the trend of China's value-added exports to its main trading partners via both simple and complex GVC trade routes using the above identification method of GVC activity in a country's GDP creation process. The United States, the EU followed by ASEAN and East Asia have increased their value-added imports from China through GVC trade from 2007 to 2018. However, since 2018, the United States and EU's value-added imports from China via GVC trade have decreased significantly, which appears to be a result of the US–China trade war and the subsequent COVID-19 pandemic. Figures 2b and 2c depict GVC trade for simple and complex production sharing, respectively. In simple GVC trade, the US imports of value-added from China have declined even more than the EU and East Asia since 2018, whereas ASEAN has shown an increasing trend. However, when compared with the simple GVC trade, each economy's movements in the complex GVC trade are generally on the decline. Another noteworthy point is the change in the value-added imports of the United States from China since 2019, as shown in Figure 2d; there is an increase in imports through complex GVC trade, whereas imports through simple GVC trade are decreasing. This is a manifestation of how the US final demand highly relies on China's value-added through complex GVC trade during the COVID-19 pandemic. This phenomenon could be explained in part by the fact that China's value-added exports via complex GVC trade have the characteristics of detour trade, which are not directly subject to US tariff sanctions because they originate in China but arrive in the United States via a third country. Furthermore, China's rapid recovery of domestic production in the aftermath of the COVID-19 pandemic allowed similar products from other countries that were in short supply to reach the United States via a complex GVC. Figure 2 confirms the trend of value creation through GVC trade, but the COVID-19 pandemic also exists behind the US–China trade war, and the pure impact of the US–China trade war cannot be decomposed and identified by simple trend analysis. Section 5 applies the CGE model to simulate the impact on GVCs of a trade war between the United States and China.

4. US–China relations in GVC trade networks

4.1 GVC trade network analytical tools

MNEs are the primary designers of this GVC game. In fact, MNEs account for roughly half of global trade, one-third of output and GDP, and one-fourth of global employment (Cathlin et al. 2019), and 80% of trade takes place in "value chains" linked to MNEs (UNCTAD 2013). To investigate US–China relations along GVCs, this section uses the identification method of GVC trade introduced in the previous section and extends our analysis to include MNE activities by using a network analysis tool. We focus on the position of countries and their control power of value capturing, using the ICT value chain as a case study.

Recently, the Organization for Economic Cooperation and Development (OECD) created new intercountry input–output (ICIO) tables (AMNE: Activity of Multinational Enterprises database) that consider MNEs' activities (Cadestin et al. 2018), which further divide production activities within each country based on firm ownership, whether domestic or foreign-owned. GVC trade can be mapped in greater detail as a result of this, allowing not only the identification of the source country and industry but also the origin of the value-added creator by firm ownership.

Miroudot and Ye (2021) proposed a framework that decomposes value-added in domestic sales to trace its origin and eliminate any double counting using the OECD AMNE ICIO tables. Moreover, Meng and Ye (2022) investigated the so-called smile curve phenomenon and identified MNE and domestic firm value-added gains, positions, and interdependencies along GVCs. Their research, however, focuses on the identification of smile curves rather than the following critical issues: 1) Are GVCs truly global or a regional phenomenon? 2) Who truly dominates GVCs? Domestic or multinational corporations? These issues are critical for better understanding the impacts on the global economy of both the primary trade liberalization directions (regional vs. multilateral trade) and the evolution of economic interdependence across countries over time and how better GVC governance should be. To address these concerns, Xiao et al. (2020) extended existing network analyses using the ICIO-based TiVA measure and concluded that GVCs are more likely organized regionally and dominated by large countries such as the United States, China, and Germany. However, at the sector level, what GVCs look like largely depends on the perspective (supply or demand) and the type of network used. That conclusion significantly improves our understanding of GVC topology, providing a balanced view between Los et al. (2015) and Baldwin and Lopez-Gonzalez (2015). The former found that a shift from regional production networks to the "Factory World" occurred in almost all production chains between 1995 and 2011. The latter asserts more boldly that "supply chain trade is not global—it is regional" and that "the global production network is marked by regional blocs that could be called Factory Asia, Factory North America, and Factory Europe."

However, the preceding studies on the topology of GVCs using ICIO models and network analysis tools are only by country and sector, and none of them explicitly consider the role of firm control (e.g., by firm ownership). As a response, this section applies the concept of bilateral trade in value-added (Johnson and Noguera 2012; Koopman et al. 2014), Meng and Ye's (2022) recent accounting framework for capturing GVC activities with clear distinctions between domestic firms and MNEs, and Suder et al. (2015), Xiao et al. (2020), Gao et al. (2021)'s network-based analytical framework. We aim to re-map the GVC topology and its evolution over time and show which type of firm (domestic or MNEs) dominates GVCs in which way (different channels of value-added trade: traditional trade, simple GVC trade, and complex GVC trade) and to what extent.

4.2 US–China relations along the ICT GVC

Figure 3 depicts GVC trade networks in the ICT industry using OECD AMNE ICIO data. These data cover 34 industries in 60 countries from 2005 to 2016, with each industry subdivided into MNEs and domestic firms. First, let us go over how to read this diagram. Figures 3a and 3b show networks formed by simple and complex GVC trade, respectively. The upper half of the graph depicts networks dominated by domestic firms, whereas the lower half depicts networks dominated by MNEs. The situations in 2005 and 2016 are represented on the left and right sides, respectively. The size of a bubble in our network figures represents a country's value-added exports of the global total for the ICT industry. The thickness of the arrow represents the share of value-added flow between each trading partner in the global total value-added flow. The direction of the value-added flow is indicated by the point of the arrow. Note that whether or not there is an arrow in the network figures is determined by two criteria: (1) if country A takes the greatest share of value-added imports from country B, there will be an arrow leading from A to B, or (2) if country A's share of value-added imports from country B is greater than 25%, there will be an arrow leading from A to B. The first is the "Top 1" threshold, which is widely used in network analysis to identify the most important arcs or links. The second standard is used to adjust network density and thus avoid omitting other important linkages. We must emphasize that the arrows we find connecting nodes in the complex GVC trade networks have nothing to do with any direct bilateral trade partners. It is used to investigate the complexities of the entire structure of interactions among countries that are indirectly linked with one another in terms of value-added trade via third countries. Note that the country name in the bubble in the lower half of the figure refers to MNEs with foreign ownership that are based in the country.

As shown in the upper half of Figure 3a, both China and the United States were global supply centers in 2005, in a simple GVC trading network dominated by domestic firms. The number of arrows shows that more countries rely on China's value-added exports than the United States, and the size of the bubble shows that the United States slightly outnumbers China in terms of value-added exports. East Asian countries/regions[1] (South Korea, Japan, and Chinese Taipei) can be thought of as regional value-added supply hubs. According to the thickness and direction of the arrow, the United States' final demand is heavily reliant on China's value-added exports, whereas China's final demand is heavily reliant on South Korea and Chinese Taipei. However, Chinese Taipei's final demand is heavily reliant on Japan and South Korea, whereas Japan's final demand is heavily reliant on China. China's position as a global value-added supply center did not change significantly in 2016, but China's presence did. This is supported by the fact that the number of arrows originating in China has increased, and the size of the Chinese bubble has surpassed that of the United States. When comparing the 2 years, the most

[1] Country/region names in this paper follow the terminology used in the OECD AMNE database.

noticeable change in topology is the loss of South Korea, Chinese Taipei, and Japan, which were regional value-added supply hubs in East Asia. It can be seen that the links between these countries/regions vanished, and they were absorbed by the network dominated by China at the same time. The direction of the arrow on the figure easily confirms how many countries globally rely on the value-added supply dominated by Chinese domestic firms, and we can also see how China relies heavily on the value-added supply of domestic firms in South Korea and Chinese Taipei.

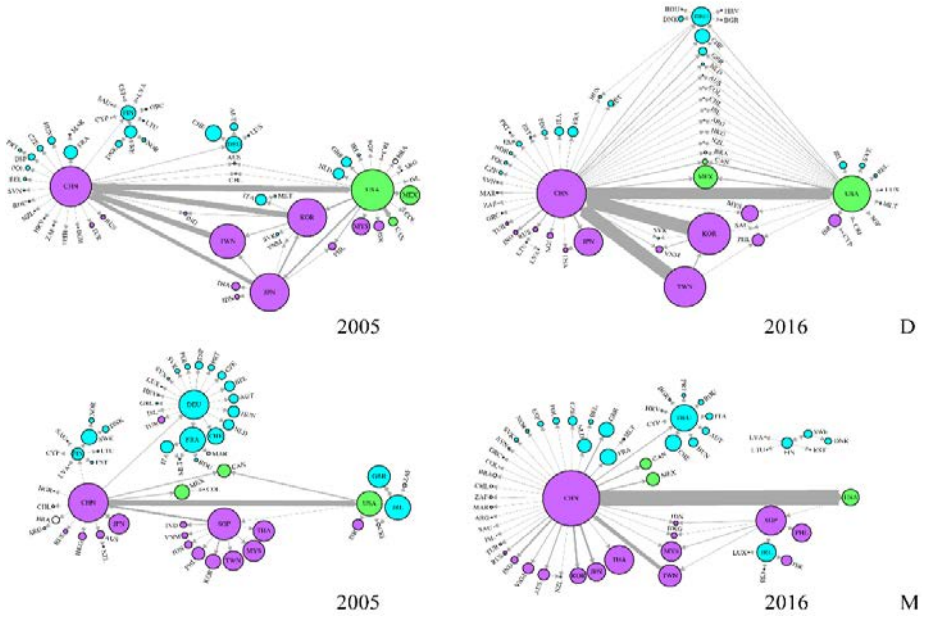

Figure 3a. Simple GVC networks of the ICT industry

Note: D and M represent domestic firms and MNEs, respectively.

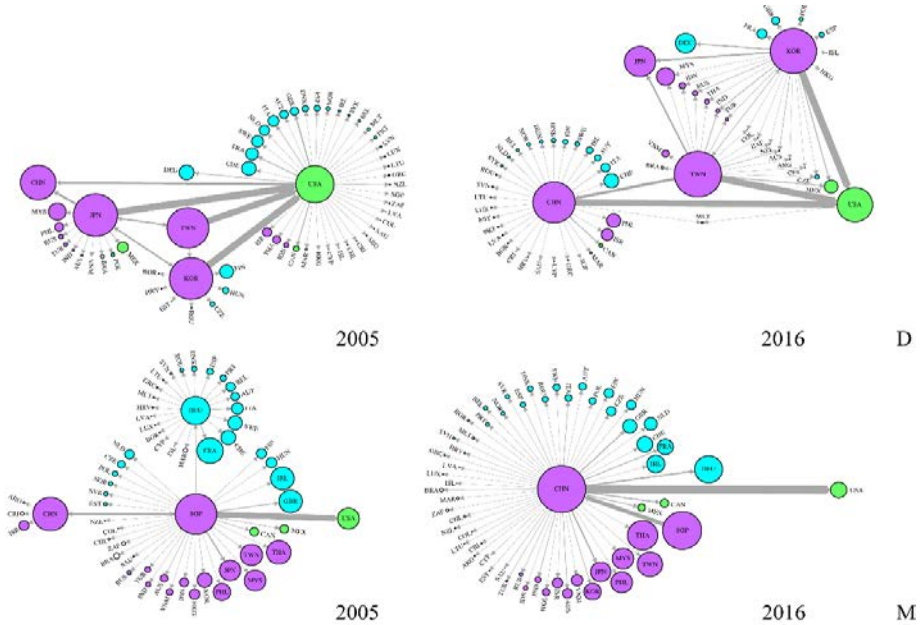

Figure 3b. Complex GVC networks of the ICT industry

Note: D and M represent domestic firms and MNEs, respectively.

The network of value-added trade dominated by MNEs with foreign ownership located in each country can be seen in the lower half of the figure. Obviously, it differs greatly from the network topology dominated by domestic firms. MNEs in Germany and Singapore were value-added supply centers in Europe and Asia, respectively, in 2005. Although China had the highest value-added supply of MNEs, it did not serve as a regional supply center in terms of the number of countries that rely on it. By 2016, it was discovered that MNEs based in China had become the sole global supply center. This is supported by the size of the bubble and the number of arrows emanating from China. By contrast, the presence of MNEs based in Germany and Singapore is declining at the same time. East Asian and ASEAN countries/regions, particularly South Korea, Chinese Taipei, Thailand, Vietnam, and Indonesia, which rely on the value-added supply of MNEs based in Singapore in 2005, were clearly sucked into the MNE-dominated network based in China in 2016. There are two things to keep in mind here. First, MNEs based in China's value-added exports have become increasingly reliant on US final demand. The change in the thickness of the arrow pointing from China to the United States demonstrates this. The second point is that Chinese Taipei, which relied on Singapore in 2005, established a thick arrow with China in both directions in 2016. This exemplifies the strong interdependence of MNEs based in China and Chinese Taipei.

The aforementioned network analysis of simple GVC trade represents the situation of shorter GVCs because it refers to a one-time cross-border intermediate goods trade. Meanwhile, longer and more complex GVC networks form when production sharing occurs at least twice across national borders. Figure 3b depicts a network of the ICT industry's complex GVC trade. First, in the network dominated by domestic firms, Japan was clearly a regional supply center in 2005, but in 2016, China, South Korea, and Chinese Taipei are segregated as supply centers rather than a centralized topology with China as the only center in the simple GVC network shown in Figure 3a. It is a manifestation of South Korea's and Chinese Taipei's strong presence in the highly complex production of intermediate goods that necessitate advanced technology. It is easy to confirm that South Korea has surpassed Japan as the most important source country of value-added imports to the United States. Another significant difference between Figure 3a and Figure 3b is that the number of countries reliant on US value-added supply through complex GVC trade has decreased, and the United States as a global supply center has specialized in supplying China. One explanation for the shifting topology of complex GVC trade is that China, South Korea, and Chinese Taipei have been able to produce more complex intermediate ICT goods, while the United States appears to be more technologically specialized in some core high-tech ICT products.

There is no discernible difference in topology between simple and complex GVC trade networks dominated by MNEs, but the growing presence of MNEs in China as a global supply center is noteworthy. For example, in the simple GVC network shown in Figure 3a in 2016, MNEs in Germany and Singapore function as supply hubs in Europe and ASEAN, respectively, but in the complex GVC

network shown in Figure 3b, they have become a part of the network dominated by MNEs in China. This is also evidence that MNEs have created complex GVC networks through FDI by producing intermediate goods in China that require more advanced technology. In fact, in the case of the iPhone X's value chain, China's share of value capture has risen to approximately 25.4% due to the supply of higher-tech intermediate goods, compared with 3.6% in the iPhone 3G value chain (Xing 2020).

Based on the network analysis presented above, let us briefly discuss the potential impact of the US–China trade war on GVCs. First, most countries and regions, including the United States, rely heavily on China's value-added exports in ICT GVCs. Rising trade costs between the United States and China as a result of their trade war, such as tariff increases on each other, will spread through China as a supply center to countries and regions that are heavily reliant on China on the GVC, particularly South Korea, Chinese Taipei, Japan, and ASEAN. More importantly, tariffs are uniform for each product, so it makes no difference whether the exporter is a Chinese domestic company or an MNE located in China. According to network analysis results, the degree of reliance on a centralized supply center is higher for MENs located in China than for value chains dominated by Chinese domestic ICT firms. In other words, the tariff increase imposed by the United States on China will have a greater impact on MNEs based in China, potentially causing more spillover effects to other economies. This is because finding a supplier that can be replaced in the short term is difficult due to the high concentration of China-based and MENs-dominated GVCs.

5. Impact of US–China trade war via GVCs

5.1 Tit-for-tat tariff battle between the United States and China

First, let us take a quick look back at the trade war between the United States and China. On July 6, 2018, the United States imposed an additional 25% tariff on 818 items (worth US$34 billion) imported from China. China has also imposed 25% tariffs on 545 items (worth US$34 billion) imported from the United States. The United States and China implemented their second tariff measure on August 23. The number of items is 284 by the United States and 333 by China, with a total value of approximately US$16 billion and an additional 25% tariff is levied. Additionally, on September 24, the United States and China implemented a third additional tariff measure. The additional tariff rate was set at 10% until the end of 2018 and 25% afterward. The withdrawal target in the United States was 5,745 items on a scale of US$200 billion, and the Chinese side was 5,207 items on a scale of US$62 billion. Then, in December, the US–China summit met in Buenos Aires, which also hosted the G20 summit. Trade disputes were discussed, and the two countries agreed to withhold a 25% tariff increase for 90 days (until February 28, 2019). Following that, the US tariff on China was 21.2%, and the Chinese tariff on the United States was 19.3% in the first formal agreement. According to Bown (2021), tariffs affect 66.4% of China's exports to the United States and 58.3% of US exports to China.

5.2 A brief introduction of the CGE model used

The Global Trade Analysis Project (GTAP) (Hertel 1997) CGE model is used in this section, but we made the following extensions to the basic model for our own research purposes. First, as described by Koopman et al. (2013) and Cai et al. (2015), the GVC element was introduced into the conventional GTAP model and the data from the ICIO tables were used to identify intermediate imports by country of origin in the sectoral production function. This allows us to reflect on the reality of GVCs that are in agreement with the actual conditions of international production sharing. The impacts of the US–China trade war can then be expressed not only in conventional economic indicators such as GDP but also in various GVC indicators such as participation and length, by constructing a new IO table from the results for which an equilibrium solution is required and applying it to the GVC account based on trade in value-added.

5.3 Scenario setting for the US–China trade war

The main scenarios of the US–China trade war are based on tariff data and US export restrictions to China. Tariffs were gradually raised in 2018 and 2019, and the first agreement on tariff negotiations between the United States and China in January 2020 reduced tariffs only slightly. Tariffs may change during negotiations between the two countries, but it is difficult to predict at this point, and any assumption will entail some degree of arbitrariness; hence, for the sake of simplification, we assume that the later tariff rate after the first agreement will continue until 2025. The detailed tariff list published by both the United States and China is combined with the HS (Harmonized Commodity Description and Coding System) six-digit level information of the United Nations Trade Statistics (COMTRADE), and the HS six-digit product classification is further linked to the GTAP industrial classification in the model simulation. Besides US sanctions against China and China's retaliation against the United States due to tariffs, the model includes export restrictions on US high-tech products to China as a scenario. To accomplish this, we convert the product classification (ECCN: Export Control Classification Number, etc.) used for export control published by the US Department of Commerce's Bureau of Industry and Security (BIS) to the aforementioned product and industrial classification (HS and GTAP industries). Based on the converted results, from 2014 to 2020, the items on the restricted list published by BIS accounted for 19% of US exports to China on average, and approximately 85% of the items on the restricted list published by BIS can be fully linked to HS. Consequently, we can say that the model's export restriction scenario explains approximately 85% of the actual restriction. Furthermore, in the first agreement, China promised the United States to purchase US$33 billion in agricultural products within 2 years, which is not a tariff shock and will be incorporated into the model as a nontariff shock.

5.4 Simulation results of the US–China trade war

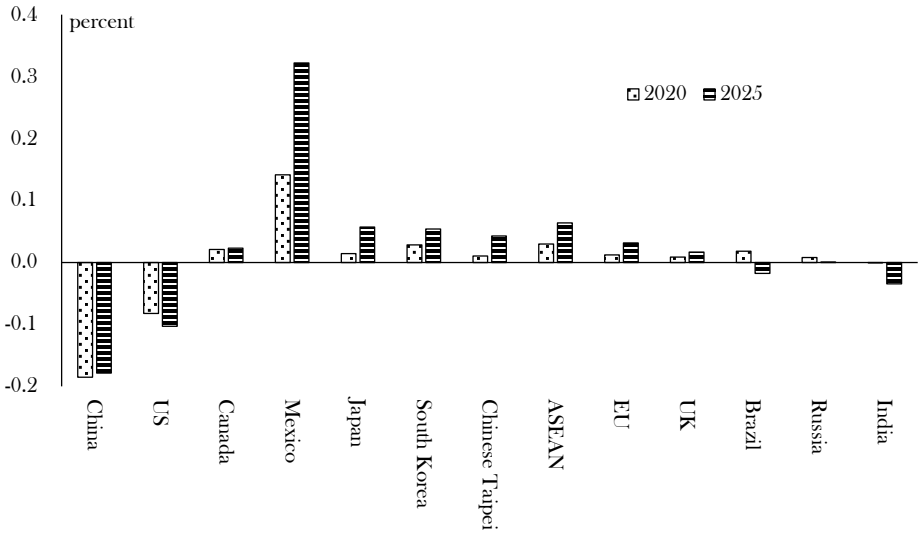

Figure 4. Impact of the US–China trade war on GDP

Figure 4 depicts the impact of the trade war between the United States and China on GDP in each country and region. It can be seen that the United States and China, which are direct participants in the US–China trade war, suffer GDP losses of 0.082% and 0.185%, respectively, in 2020. China's loss, as measured by GDP ratio, is more than double that of the United States, and China's loss is 1.586 times greater than that of the United States in absolute terms, given the economies of both countries. This is primarily because China's value-added exports are heavily reliant on the US final demand and imports of US high-tech intermediate goods, and the strength of US tariffs and export restrictions on China is much stronger than that of China does on the United States. However, a positive effect is seen on the GDP of other countries/regions, particularly the increase in GDP of Mexico, South Korea, and ASEAN. This is partly due to US sanctions on China, which have caused the prices of China's final goods exports to the United States to rise. It also means that similar products made in Mexico, South Korea, and ASEAN and exported to the United States are becoming more affordable. Note that a decrease in China's exports to the United States should have a negative impact on the supply of intermediate goods made in South Korea, which is located upstream of China's value chain. The net effect of the US–China trade war on South Korean GDP, however, remains positive, because the positive substitution effect due to price changes in final goods outweighs the negative complementary effect due to linkages through the supply of intermediate goods along GVCs. During this type of simulation analysis, keep in mind that very complex reactions across countries occur in the system due to both substitution and complementary channels.

As shown in the figure, there are no significant differences between the basic situation in 2025 and that in 2020. However, some changes are observed in the magnitude and direction of GDP changes for individual countries. First, if the trade war continues until 2025, both the United States and China will suffer GDP losses, but the loss in the United States will be greater than the loss in China by GDP ratio. It can be explained by the following factors. First, China is the world's factory for exporting finished goods; it has also become capable of supplying the world market with more sophisticated and complex intermediate and capital goods. If the United States and China engage in a long-term trade war, the cost of acquiring China-made intermediate and capital goods in the United States may rise, reducing the productivity of US firms that use these goods and resulting in a loss of GDP. Furthermore, as a result of US export restrictions to China, China's import and procurement sources for high-tech intermediate goods should shift away from the United States and toward countries or regions with similar product manufacturing capabilities, such as Japan, Germany, South Korea, and Chinese Taipei. Consequently, it contributes to the increase in GDP of US competitors and the loss of GDP of the United States itself. In fact, as can be seen from the figure, in 2025, the magnitude of GDP growth in Japan, Chinese Taipei, South Korea, and the EU will be higher than in 2020. The obvious difference between the 2020 results is that GDP changes in India and Brazil have shifted from positive to negative. Some factors can be considered. For example, because both India and Brazil are located upstream of China's value chain, which is focused on the supply of low-value-added products such as raw materials, China's decrease in exports to the United States could have a spillover effect on both countries' exports to China, resulting in a loss in GDP. However, as the US–China trade war prolongs, some of China's production capacity will be transferred internationally to avoid high tariffs, and those countries appear to be ASEAN rather than India and Brazil in terms of geography and infrastructure development. Indeed, as shown in the graph, ASEAN's GDP growth in 2025 will be remarkable. Furthermore, India and Brazil lack the production technology for high-tech intermediate goods that Japan, South Korea, and Chinese Taipei do and thus cannot be considered an alternative to China's reduction in intermediate goods imports from the United States. Consequently, there are few options for both India and Brazil to offset the GDP loss caused by the trade war between the United States and China. It should be noted here that from the GDP change rate on the figure, the third countries or regions might profit from the US–China trade war, but considering the economic scale of the United States and China, the world overall GDP will be negatively impacted.

Figure 5 shows the impact of GDP loss of the US–China trade way by trading route using the concept of trade in value-added presented in Section 2. Take 2020 as an example, adding value could be achieved through three channels: traditional trade (final goods trade), simple GVC trade (intermediate goods trade that crosses borders only once), and complex GVC trade (intermediate goods that cross borders at least twice). Clearly, only the United States and China have a negative impact on traditional and simple GVC trade, and the magnitude is enormous. Also, in China's case, the impact on

traditional trade is greater than in simple GVC trade, and the United States shows the opposite pattern. There are several reasons for this. First, the United States and China are parties to the trade war, and if they impose a tariff of approximately 20% on each other, they will naturally suffer great and direct damage. Second, because China's exports to the United States are mainly low value-added final goods and the United States' exports to China are mainly high value-added intermediate goods, it is easy to understand that relatively larger losses of traditional trade in China and simple GVC trade in the United States happen. Third, the US export restrictions to China are on high-tech intermediate goods, which in turn causes a decrease in the United States' own value-added creation via simple GVC trade. Unlike in the United States and China, other countries and regions benefit from both traditional and simple GVC trade. It is clear that China's export competitors, including the EU, Japan, Mexico, Canada, and ASEAN, may benefit from the substitution effect of rising tariff barriers between the United States and China.

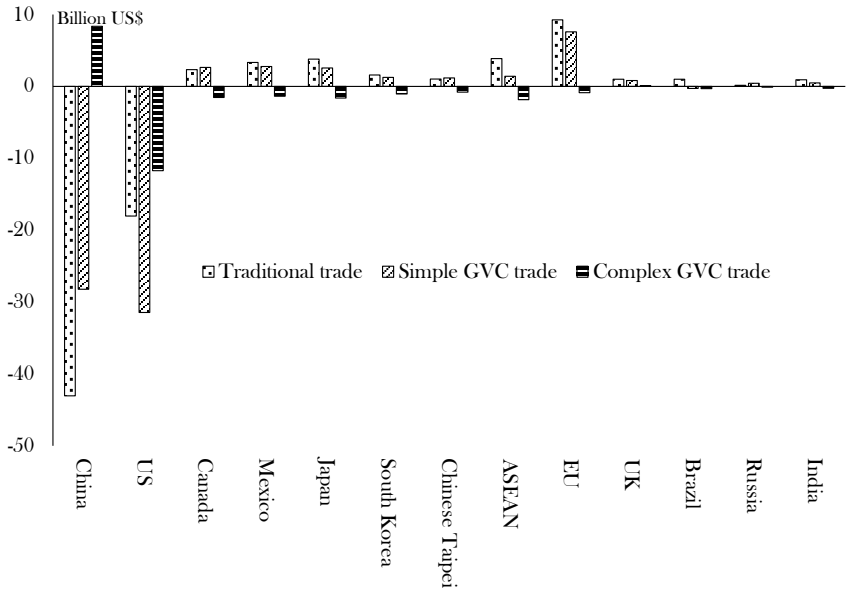

Figure 5. Impact of the US–China trade war on value-added exports by trade route

However, as can be seen from the figure, the impact on the complex GVC trade is quite different from the former two routes. Only China will be positively affected, and other countries/regions, including the United States, will have negative effects. It is easy to confirm that such results are consistent with Figure 2d in Section 1, which depicts actual GVC trade between the United States and China. This could be due to several factors. First, as aforementioned, complex GVC trade crosses national borders more than once, so it can be thought of as detour trade. For example, if Chinese metal parts are first exported to Vietnam, which will be used to manufacture frying pans as final goods and then exported to the United States, the added value of China will be absorbed by the final demand of the United States via Vietnam. This will result in China's value-added exports to the United States via the complicated GVC trade.

These routes are not directly affected by US–China tariff increases or US export restrictions to China, but they may become more popular as an alternative route for Chinese-made frying pans to be exported to the United States. However, the decline in China's traditional trade exports to the United States as a result of the US–China trade war will impact the export of intermediate goods to China in countries and regions located upstream of China's value chain. For example, a decrease in Chinese-made smartphone exports to the United States will reduce demand for intermediate goods such as US IC chips, Japanese small cameras, and Korean touch panels used in smartphone production. In this case, value-added exports to the United States, Japan, and South Korea via complex GVC trade may decline. As shown in the figure, the US–China trade war has resulted in the greatest decrease in value-added exports via the complex GVC trade in the United States. This highly relates to the fact that the United States once exports a large amount of high-tech intermediate goods to China (which may actually go through a third country), assembles them into final goods in China, and finally reaches US consumers along GVCs. In other words, the US final demand causes its own value-added via reimports. Indeed, as demonstrated by Koopman et al. (2014), such value-added creation in the United States accounts for 11.3% of total value-added exports (the world average is only 3.4%).

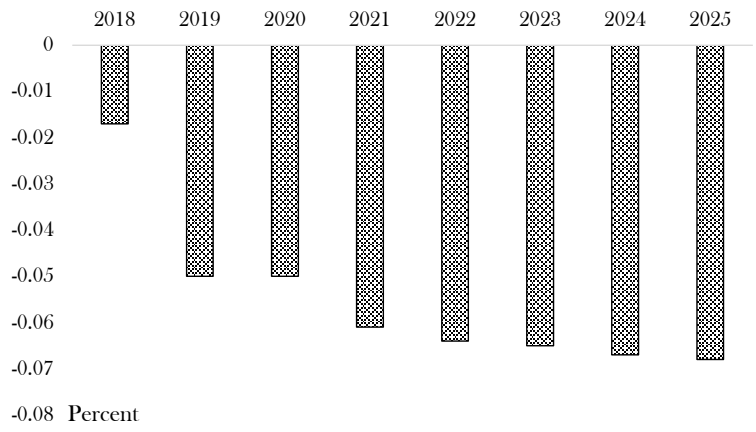

Figure 6. Impact of the US–China trade war on the length of GVCs.

Finally, the trade war between the United States and China is likely to raise the cost and risk of arranging the entire GVC, resulting in shorter GVCs. Figure 6 depicts the results of a simulation analysis to determine how short it could become. The length of GVCs is measured by the number of stages weighted by value-added creation in each stage that a product goes through before reaching the final demand (Wang et al. 2017). Figure 6 depicts the annual change in GVC length if the US–China trade war continues until 2025. Clearly, the shortening pattern of GVC length is similar to the trend of the US–China tariff tit-for-tat descripted in Section 5.1.

6. Considering the GVC restructuring under the US–China trade war

6.1 GVC "stability" vs. "GVC vulnerability"

GVC development is an irreversible spring tide for the international division of labor accompanying the spread of technology. GVCs are intricately intertwined with US–China relations. Its forced decoupling would cause far more than just surface damage in both countries. Rather than such a decoupling, the intimate nature of the two countries' economic ties has kept their dispute in check, and no critical situation like the one witnessed in the US–Soviet Union conflict has yet to be reached. A complete decoupling could result in the conditions foreseen by Alibaba's Jack Ma: "If trade stops, war starts" (Yoo 2017). The United States has imposed unprecedented sanctions on China's Huawei, but export restrictions have been postponed several times. The reason for this is to reduce losses for both US suppliers in Huawei's GVC upstream and US equipment users in its downstream. Furthermore, the GVC "game" being played here between the two countries is that each has major power status, resulting in incalculable potential incurred damages. Regardless of how loud the start of hostilities is, for major powers, complete decoupling is a means of causing the other side to compromise rather than the end goal. However, progress in partial decoupling between the United States and China by individual area is possible. One example is high-performance semiconductor chips. The effects here have the potential to reach innovative technologies such as 5G, AI (artificial intelligence), IoT (the internet of things), and others, which are at the heart of the fourth industrial revolution. Therefore, the future state of GVC governance will be determined by the extent to which partial decoupling between the United States and China is managed, and other countries' policy responses.

6.2 "China risks" vs. "China opportunities"

Many countries are currently cautious of "China Risks," whereas businesses are wary of "China Opportunities." In 2019, China had a gross national income of US$10,410 per capita (US$15,320 adjusted for purchasing power parity) (IMF 2020) and continued its transition from a developing country to a developed one (with the dividing line from 2018 to 2020 set at US$12,235 by both the UN and the World Bank) (Kumagai 2018). In fact, according to estimations based on the statistics of the US Department of Commerce, in 2017, total sales to China for US companies exceeded total sales to the United States for Chinese companies (Zhang et al. 2018). Although the US–China conflict may transition into a long-term situation, it is predicted that China will shift in the middle- to long-term from being "the world's factory" to being a "center of global demand" that rivals the United States, with large-scale demand not only for its intermediate goods but also for its final goods (Xiao et al. 2020). Apparently, there will be a major shift in the GVC strategies of local subsidiaries of MNEs from creating products "in China for the world" to "in China for China."

6.3 Contradictory stances between the United States and China

The contradictory stances of the United States and China, which are causing conflicts in GVCs, can be summarized as follows. The first point is about the developing country's status. China is currently classified as a developing country in international organizations such as the WTO. On the other hand, the United States is completely unconvinced on this subject and strongly insists on reforming developing-country status in the WTO. The second point is about intellectual property and the transfer of technology. China appeals to the advancement of undeveloped countries and to the legitimacy of the "exchange of technology via markets." The United States claims that this amount to "forced technology transfers" that lead to losses for the United States as a country. The third point is about the state-owned firms. China claims that state-led industrial policies with state-owned firms at their core are indispensable for economic development. The United States claims that free-market competition should be pursued; criticizes the opacity of state-owned firms. The fourth point is about the treatment of personal information. China places management concerning the collection, accumulation, and analysis of big data under the guidance of the state. The United States leaves management concerning the collection, accumulation, and analysis of big data to the guidance of firms. Considering what each country emphasizes for their national interests, as things currently stand, room for compromise and concession is very limited for each aforementioned stance.

The key point here is that as long as there are contradictions between the United States and China against the backdrop of their conflict, there will always be agreement among Republicans and Democrats in the increasingly divided United States about the unyielding stance toward China. Therefore, the US–China conflict shows signs of developing into a long-term battle that extends to targets ranging from trade and technology to financial, social systems, and the rule-making of international governance.

6.4 Outlook of the US–China relations regarding GVC governance

Given the above discussion, we could give the outlook of the US–China relations:

1. The United States will become a country that emphasizes relative gains over absolute gains, regardless of administrative replacement, and it will not break away from its hardline stance against China. However, compared with the Trump administration, the Biden administration will be more predictable in its operation.
2. China will seem to be a country that is neither a "developed country" in terms of western values nor a "developing country" in terms of its power. It will shift from being "the world's factory" to a "global market" of the largest scope.
3. GVC developments are irreversible, but the United States and China will move into a period

where “conflict, competition, and cooperation” coexist in a partial decoupling situation by field under control based on the tug-of-war between the two.

4. From a GVC perspective, it seems that the United States and China have both left their domestic economies with enough strategic choices to sufficiently endure partial decoupling. It is countries besides the United States and China that highly rely on the GVC and have scant cushioning to absorb external shocks that could easily find themselves facing severe blows.

5. The main challenge for the future of GVCs is more institutional and political in nature rather than technological. If the ongoing US–China trade conflicts and the COVID-19 crisis aggravate more policy tensions across countries, especially between the United States and China, the future of GVCs will not be optimistic. In this sense, the international rule-making for trustable GVCs concerning the data, intellectual property, mergers and acquisitions, and the scope of national security-related issues will greatly determine whether and to what extent GVCs could be further deepened.

Finally, regarding the readiness of individuals, companies, and governments involved in the GVC, I want to borrow the words of mathematician John Allen Paulos to conclude this paper:
“Uncertainty is the only certainty there is, and knowing how to live with insecurity is the only security.”

Appendix. Country/region code used in Figure 3

OECD code	OECD countries	Non-OECD code	Non-OECD economies
AUS 1	Australia	ARG 37	Argentina
AUT 2	Austria	BRA 38	Brazil
BEL 3	Belgium	BGR 39	Bulgaria
CAN 4	Canada	CHN 40	China (People's Republic of)
CHL 5	Chile	COL 41	Colombia
CZE 6	Czech Republic	CRI 42	Costa Rica
DNK 7	Denmark	HRV 43	Croatia
EST 8	Estonia	CYP 44	Cyprus
FIN 9	Finland	IND 45	India
FRA 10	France	IDN 46	Indonesia
DEU 11	Germany	HKG 47	Hong Kong, China
GRC 12	Greece	MYS 48	Malaysia
HUN 13	Hungary	MLT 49	Malta
ISL 14	Iceland	MAR 50	Morocco
IRL 15	Ireland	PHL 51	Philippines
ISR 16	Israel	ROU 52	Romania
ITA 17	Italy	RUS 53	Russian Federation
JPN 18	Japan	SAU 54	Saudi Arabia
KOR 19	Korea	SGP 55	Singapore
LVA 20	Latvia	ZAF 56	South Africa
LTU 21	Lithuania	TWN 57	Taipei,China
LUX 22	Luxembourg	THA 58	Thailand
MEX 23	Mexico	VNM 59	Viet Nam
NLD 24	Netherlands	ROW 60	Rest of the World
NZL 25	New Zealand		
NOR 26	Norway		
POL 27	Poland		
PRT 28	Portugal		
SVK 29	Slovak Republic		
SVN 30	Slovenia		
ESP 31	Spain		
SWE 32	Sweden		
CHE 33	Switzerland		
TUR 34	Turkey		
GBR 35	United Kingdom		
USA 36	United States		

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