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Measuring the Welfare Effects of the US-China Trade War Using a Computable General Equilibrium Model

Master's thesis

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Declaration of Authorship

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Abstract

This study analyzes the trade war between the United States (US) and China using the GTAP (Global Trade Analysis Project) CGE (Computable General Equilibrium) model. Five scenarios focused on economic decoupling are analyzed: 1. Mutual tariff levels increased to 25%, 2. Mutual tariff levels increased to 45%, 3. Bilateral export levels decreased by 25%, 4. Bilateral export levels decreased by 45%, and 5. Trade efficiency decreased by 10%. The analysis shows both the US and China's consumer welfare and GDP decreased across all scenarios, with a larger decrease in China. In addition, when exports from China and the United States decrease, there is an increase in exports from the ASEAN region.

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Contents

List of Tables

List of Figures

Acronyms

ASEAN Association of Southeast Asian Nations

CDE Constant Difference of Elasticity

CES Constant Elasticity of Substitution

CGE Computable General Equilibrium

CPI Consumer Price Index

EU European Union

EV Equivalent Variation

GDP Gross Domestic Product

GTAP Global Trade Analysis Project

IMF International Moneytary Fund

IO Input-Output

MFN Most Favored Nation

NIPA National Income and Product Account

SAM Social Accounting Matrix

TPP Trans-Pacific Partnership

US United States

USTR United States Trade Representative

WTO World Trade Organization

Master's Thesis Proposal

Author	Bc. HaEun Kim
Supervisor	Vilem Semerak Ph.D.
Proposed topic	Measuring the Welfare Effects of the US-China Trade War Using a Computable General Equilibrium Model

Motivation In 2018, the US imposed a 25 percent tariff on 284 imported Chinese products (worth US$16 billion) and China promptly responded with a 25 percent retaliatory tariffs on 545 US goods (worth US$34 billion), accusing the US of triggering "the largest trade war in economic history to date". The disputes between the world's largest economies are escalating despite continued trade negotiations. As a consequence, global value chains, which have been centered in China for the past 20 years, have started to collapse and the international trade has been under inevitable pressure.

Global value chains refer to the international fragmentation of production network with processes ranging from product design, procurement, manufacturing, distribution, and sales. Primarily, the US has provided key technologies in global value chain and China has been a final assembler for producing products. However, China has shown its ambition to lead high-tech industries through its 'Made in China 2025' plan, aiming to be fully self sufficient for domestic companies and to lead the global market. In response the US added Huawei, a flagship company of China, to a trade blacklist with the intention to exclude China from the global supply chain. As the trade war continues, more and more international companies are considering to move their production bases from China.

The heavy tariffs imposed by the trade war harms consumers by making foreign goods expensive. At the same time, domestic industries are protected from foreign competitors and the government gains tariff revenues. The ongoing trade war will not only affect the overall macroeconomic performance of both the US and Chinese economies but also will result in a big shift in the global value chain. Through this paper, I will delve into inevitable decoupling of US and Chinese economies. Using computable general equilibrium(CGE) model, I will estimate welfare effects in both economies and investigate the possible changes in global value chains.

Hypotheses

Hypothesis #1: The trade war will lower the consumer welfare of both the US and China.

Hypothesis #2: The economic decoupling will have a significant negative impact on China's manufacturing sector and the US service sector.

Hypothesis #3: Intermediate trade will largely shift from China to Southeast Asian countries.

Methodology International organizations and research institutes such as IMF have been analyzing the impact of the US-China trade disputes using methodologies such as the World Input-Output Database(WIOD) analysis, panel data analysis, and CGE analysis. CGE analysis enables researchers to quantify the effect of changes in trade policy throughout all different parts of domestic economy, with the advantage of having both theoretical basis and data-based calibration.

Hence, a CGE model will be used in the paper. Dataset will be obtained from the WITS(World Integrated Trade Solution), OECD TiVA(Trade inValue Added) and GTAP(Global Trade Analysis Project) database. I will construct a structural model of the economy and calibrate it using the Social Accounting Matrix obtained from the data. In order to assess the counterfactual effects of trade wars, I will adjust policy variables like tariffs and compute the changes in equilibrium. This CGE model will build upon models in Wing(2004) and Balistreri et al.(2018) focusing on the trade between the US and China. The model will make use of the widely used programming language Generalized Algebraic Modeling System(GAMS).

Expected Contribution A number of studies used CGE models to estimate the potential economic effects of trade wars under various scenarios. Most of them used the GTAP database for counterfactual simulations. I will also make use of the GTAP database, complemented by the OECD and WITS databases in order to estimate the changes on global value chain. Following the other studies, I will construct the general equilibrium model of the US and China, and measure the welfare effects of the ongoing trade war using the most recent data available. My aim is to focus on scenarios of the economic decoupling of the US and China. The two countries may already be in the process of economic decoupling. The estimated economic impact on the two countries would depend on the degree and speed of decoupling assumed.

Outline

1. Introduction and motivation
2. Literature review
3. Econometric model and data
4. Empirical results
5. Conclusions
6. References

Core bibliography

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Author Supervisor

Chapter 1

Introduction

When two of the world's largest economies enter into a trade war, the global impact will not be small. The current trade war between the United States and China seems to have started when the Trump administration came to power, but the core quarrels and grievances have been brewing for the last twenty years. The Obama administration filed sixteen complaints against China with the World Trade Organization (WTO) from 2008 to 2016, on topics ranging from China's unfair subsidy policy to intellectual property rights violations. However, these trade conflicts were mostly dealt with in a traditional fashion without the struggle turning into an outright trade war. The Trump administration's announcing massive tariff hikes on China in 2018 marked the beginning of the trade war, against which China did not hesitate to hit back on with retaliatory tariffs.

Since then, the US and China have been fighting a war that was not slowed by the four rounds of tariff raises that followed over the next three years. Although an agreement to address the conflict was reached for the first time through the Phase One deal on January 15, 2020, the deal was only a cursory eighty-six pages, while the average American trade deal often stretches into thousands. The United States' dissatisfaction with China has been building up, as China shows its ambitions for further economic growth. Although large-scale tariff hikes have been made, the process of the two countries becoming less dependent on each other, otherwise known as economic decoupling, is likely to continue into the future as these core conflicts will remain.

Hence, the aim of this paper is to analyze the effects of the US-China trade war from a decoupling point of view. On the political situation between the United States and China, there is a view that the trade war is not only an economic but also a strategic conflict. However, this paper mainly focuses on estimating its macroeconomic aspects and direct costs. First, the effects of tariff increases are analyzed; then the economic change when the amount of trade is reduced without tariff hikes is estimated. Finally, the case where the trade efficiency decreases while all conditions remain the same is analyzed.

As the analysis method, the Global Trade Analysis Project (GTAP) Computable General Equilibrium (CGE) model is employed. The GTAP CGE model is widely used by many researchers as well as international institutions and governments for trade and policy analysis. As a recent example, the World Trade Organization developed and announced the WTO Global Trade Model, an extension of the GTAP model, to access the effects of global and national trade policies (Aguiar *et al.* 2019). Moreover, the GTAP model was used by the US government to evaluate the effect of import tariffs on steel in the early stages of the trade war (US Department of Commerce 2018).

This paper proceeds as follows: in Chapter 2, previous studies on trade disputes and modeling approaches are presented. Although there have been theoretical and empirical studies on trade disputes even before the trade war between China and the US broke out, studies estimating the economic impact of trade disputes between the two countries have also actively been conducted as this particular trade war developed. Trade and policy literature using analysis techniques such as econometric estimation, gravity model, partial equilibrium model, general equilibrium model is reviewed. Many scholars have already analyzed the trade war using the CGE model, and a summary of the studies is offered in Table 2.1.

Chapter 3 provides the political and economic background necessary to understand the current US-China trade war, including its three major causes: economic factors, political strategy, and the battle for global dominance. To understand the United States' large trade deficit with China, not only the trade balance but also the current account and the global value chain must be considered. As the trade war has progressed, there has been a change in the dependence between the two countries, but the import and export items have not changed considerably.

Chapter 4 describes the CGE GTAP model, its structure, and the process of designing experiments using it. The GTAP Version 10A Data Base was used for the analysis, and 141 regions were aggregated into six regions, sixty-five industrial sectors were reclassified into eleven sectors, and eight factors were aggregated into five factors. A total of five decoupling scenarios were established. Scenarios 1 and 2 see the US and China raise tariffs by 25% and 45%. Scenarios 3 and 4 reduce bilateral trade by 25% and 45% between the two countries. Finally, in Scenario 5, the trade efficiency between the two countries decreases by 10%. All experiment specifications such as market closure, parameter values, and solution methods are disclosed in Chapter 4 and can be replicated using the GTAP model.

The results of the analysis are presented in Chapter 5. The analysis shows a decrease in the welfare and GDP of the US and China in all scenarios, with a larger decrease in China. In addition, when exports from the US and China decreased, exports from the Association of Southeast Asian (ASEAN) region increased. This redistribution of trade flows reflects the global value chain. Real return to land in the US showed substantial losses compared to other primary factors. In the United States, agricultural and motor vehicle output declined, while China's production of electrical equipment and manufacturing also declined. Exports to the United States and China declined across all industries, with shifts to other regions.

Finally, a conclusion is drawn after analyzing the sensitivity test with modified elasticities reduced by half and the limitations of this study.

Chapter 2

Literature Review

2.1 Prior Study on Trade Dispute

Since the beginning of 2018, the United States and China have been engaged in an unprecedented trade war. Conybeare (1985) has defined a "trade war" as a conflict undertaken by countries to achieve their economic goals related to trade goods, using a means of restricting the flow of goods and services. The US-China trade war is distinguished from other trade conflicts by its size and duration. Cui *et al.* (2019) argues that not only economic aspects but also political factors must be considered in order to analyze the cause of the outbreak of the US-China trade war. Kim (2019) also notes that the US-China trade war should be understood as a complex problem that reflects domestic and international political considerations, and is not simply an economic conflict that has arisen to resolve trade imbalances.

Even before the US-China trade war broke out, there had been extensive research on the causes of international trade conflicts, most of which had been conducted from an economic perspective. These studies focused on economic factors such as market price fluctuations, terms of trade, market and economic size, trade balance, trade dependency, and the diversity of trading partners (Kim 2019). The research showed that past trade disputes were likely to commence when the price of imported goods increased or the price of exported goods fell (Bagwell & Staiger 2002). Trade disputes frequently occurred as the size of markets and economies increased and trade imbalances worsened (Bown 2005). Moreover, the more diverse the trading partners and the lower their trade dependency, the higher the probability of trade disputes (Horn *et al.*

1999).

Some economists have argued that trade disputes reduce the total volume of trade and break up the trade structure between two countries (Rowley *et al.* 1995). For example, Elms (2004) estimates that trade conflicts incur high costs while causing losses on both sides by reducing exporters' and importers' profits. On the other hand, by using a partial equilibrium model, Bagwell & Staiger (2001) has suggested that trade conflict can benefit certain groups or industries in the long term even if it reduces overall economic welfare.

Much research has also been done on the role of tariffs in trade disputes. In the early trade literature, Johnson (1951) proposed an optimal tariff as a motive for a trade dispute, suggesting that increasing tariffs could be beneficial if the other country does not retaliate. Furthermore, Johson (1953) has described a situation where a country may gain by imposing an optimum tariff even if the other side retaliates. However, Rowley *et al.* (1995) has countered that the chances of a loss are too high to be realistic in such situations. Ossa (2014) has supported the theory of Johnson (1951) and was the first to empirically estimate the impact of an optimum tariff and world trade war.

Song & Lee (2018) has stated that a significant increase in tariffs would have economic consequences similar to the act of imposing anti-dumping duties, as countries implement trade remedies such as anti-dumping to discourage the import of certain products from specific countries. Significant increases in tariffs by one or both countries may have similar economic consequences as imposing anti-dumping tariffs or invoking safeguard. According to Prusa (2001) and Staiger & Wolak (1994), the net effect of anti-dumping import deterrence is determined by the investigation effects and trade diversion effects. Prusa (2001) has analyzed the effects of US anti-dumping implications on US trade and found that when the US imposed anti-dumping tariffs, imports from their trade partners decreased by about 65%, while imports from other countries increased by about 40% due to the trade diversion effect, which appears to offset much of the investigation effect. Konings & Vandenbussche (2013) has analyzed how exports from anti-dumping countries are affected by imposition and demonstrated that they may also decrease. Bown & Crowley (2007) has used data from Japan to study the impact of imports on safeguard activation as well as on anti-dumping. The research showed that when the US implemented anti-dumping and safeguards on Japan, there was a trade diversion effect on imports from Japan.

There have also been attempts to explain trade disputes by economic theory. Elms (2004) has examined why trade disputes persist even when losses continue or gains are judged to be small, and has argued that though this trade conflict situation cannot be explained by the expected utility theory, it can be understood by the prospect theory. The utility curve of the prospect theory is S-shaped, and the slope of the loss region is steeper. Accordingly, Elms (2004) has explained that the deeper the losses of the countries with trade disputes, the more risks they would choose to take to make up for these losses.

Kim (2019) used game theory to examine the possible future development of the US-China trade war under different conditions. Kim (2019) judged that the classic game theory is not suitable for analyzing the US-China trade war because the two countries have been exchanging information with each other and have held negotiations several times. Considering various economic indicators, Kim (2019) predicted that the situation would reach 'US defect-China cooperative' status in the long run because the US has higher bargaining power. Jiang *et al.* (2020) also used game theory to analyze the US trade war and concluded that the US has the upper hand. However, Jiang *et al.* (2020) has predicted that the US and China will compromise and negotiate as it is in both their best interests.

As discussed above, there have been a number of studies on the effects of a country's trade remedies, such as anti-dumping, safeguards, and countervailing duties. There have also been theoretical studies on the cost of protectionism, optimal tariffs, and trade disputes. However, studies estimating the economic effects of a trade dispute between two specific countries have also been actively conducted with the US-China trade war as a starting point.

2.2 Prior Studies of Modelling Approaches

There are several different modeling approaches in trade and policy analysis, which can be broadly divided into econometric estimation and simulation. In econometric models, parameter values are estimated using statistical techniques, whereas in simulation models, behavioral parameters are gathered from several sources and the remaining parameters are calibrated to reproduce the data of the reference year (Bacchetta *et al.* 2012). One of the representative econometric estimations used in trade analysis is the gravity model, and the types of simulation models include input-output analysis, partial equilibrium models, and general equilibrium models. Most of the research on the US-China trade war has been done with simulation models such as CGE, though there are also studies using a gravity model.

Gravity models as applied to international trade were first devised by Salette & Tinbergen (1965) and theorized by Anderson (1979). Salette & Tinbergen (1965) has assumed that the size of exports from one country to country to another is proportional to the economic size of the two countries and inversely proportional to the physical distance between the two countries. Furthermore, Anderson & Van Wincoop (2003) developed the model by deriving theoretical foundations and resolved a specification bias in the original model. Since then, the gravity model has been widely used in trade analysis not only for studying the relationship between the trade volume and the geographical distance between trading partners, but also for investigating how preferential trade agreements, non-tariff barriers, and exchange rate systems affect trade flows (Van Bergeijk & Brakman 2010).

Jackson & Shepotylo (2018) conducted a study on tariffs imposed by the US on China and the EU as of 2018 using a gravity model. Four scenarios were established depending on whether the other country were to take retaliatory measures against tariffs: (i) neither China or EU retaliate, (ii) only China retaliates, (iii) only EU retaliates, (iv) both China and EU retaliate against the US with the same level of tariffs imposed. Using a structural gravity model, Jackson & Shepotylo (2018) estimated that in all scenarios a trade war harmed the US economy, with the loss ranging from -0.25% to -1.4% of GDP. The loss was maximized when both China and the EU retaliated against the US. Kalendiene & Loda (2019) studied the impact of the US-China trade war on third countries that are mainly not involved in the dispute using a time series approach to a gravity model. The study found that of the sampled countries, only Denmark and the Netherlands benefited from increased exports when the US-China trade war broke out. Also, Kalendiene & Loda (2019) noted that not many economies were directly affected by the US-China trade war in the short term.

One of the most defining characteristics of the US-China trade war is the high tariffs imposed by both sides. The simulation models used to analyze the effects of tariffs on trade can be classified into three broad categories: partial equilibrium models, input-output analyzes, and general equilibrium models. A partial equilibrium analysis is a method of analyzing a single commodity market, assuming the other market conditions are given. The partial equilibrium analysis model has the advantage of being relatively simple and intuitive to use, as it narrowly focuses on a single industry (Hallren & Riker 2017). Partial equilibrium analysis can measure the effects of a given policy action in the market and capture complicated policy mechanisms. However, it does not reflect the feedback effects between other commodities and factor markets because it does not take into account inter-market linkages (Bacchetta *et al.* 2012). It is suitable for capturing short and medium term effects rather than long term effects (Bacchetta *et al.* 2012). Due to these characteristics, researchers who have studied the trade war have often used partial equilibrium models for short-term analysis on a particular commodity market.

Abiad *et al.* (2019) has used a multi-regional input-output table to estimate partial equilibrium effects of the trade war on developing Asian regions. A total of three scenarios were applied: (i) tariffs imposed by the United States and retaliatory tariffs by China as of October 2018, (ii) 25% tariffs on all imported goods from the United States and China, (iii) 25% tariffs imposed by the US on all autos and parts along with retaliatory tariffs from seven partner countries such as Mexico and Canada. In the third and most extreme scenario, China's GDP decreased by 1% and the US's GDP decreased by 0.2%. In the case of developing Asia, the effect of the trade war was mildly positive; Abiad *et al.* (2019) has explained this beneficial impact is due to trade redirection in electronics and textiles industries.

Input-output analysis is a modeling technique which is often used to estimate economic impact by assessing the direct and indirect interdependencies among different sectors (Munroe & Biles 2005). Its basic form consists of a system of linear equations, each describing how an industry's products are distributed throughout the economy (Miller & Blair 2009). It describes the real economy with flows of products from each industrial sector to other sectors as well as within itself. (Miller & Blair 2009) Christ (1955) posits three major assumptions of input-output analysis which ease the mathematical complexity of the analysis: constant returns to scale, no substitution among inputs, and no joint products. The model's characteristic of fully accounting for all inputs into production has been an important theoretical and empirical basis for many studies (Rose 1995).

Xia *et al.* (2019) has used an IO model to analyze the impact of the US-China trade war on global energy demand under different scenarios. The study was conducted by estimating the direct and indirect impact of the trade war on the energy sector of each country and then analyzing the issue of global energy demand. The study was analyzed with two scenarios: (i) the US imposes 25% tariffs on $50 billion worth of goods against China, and (ii) China reacts to US tariffs and imposes retaliatory tariffs on US imports. The analysis found that the US-China trade war had a negative impact on both countries, but China was more affected. It also showed that some countries benefited from the trade war in the short term, but overall it had a negative impact on the global economy. Energy demand reduced in both countries, and Xia *et al.* (2019) predicts that global energy demand would also decrease in the long run.

A general equilibrium analysis is a method of analyzing all markets at once, taking into account the interaction of one market with another. It explicitly accounts for all the links among the sectors in the economy (Bacchetta *et al.* 2012). An analysis of trade wars using the general equilibrium model has the advantage of analyzing macro-variable movements such as GDP, prices, and the trade balance, as well as the ripple effects on all industries and interactions by economic entities. Computable General Equilibrium (CGE) is a system of non-linear simultaneous equations which describes the behavior of economic agents (Scarf & Hansen 1973). By solving the optimization constraints of the economic agents such as consumers, producers, government, investors, importers, and exporters, the model computes the general equilibrium of the economy as a whole (Burfisher 2016). When an economic shock perturbs the equilibrium, the model resolves the system of equations to find a new market clearing price and quantities. Through this procedure, it provides a comparison of]before and after a shock in the economy (Burfisher 2016).

The most important difference between the IO model and the CGE model is the general equilibrium approach of the CGE model. The CGE model describes the complete economy where all products produced are used, and all incomes earned are spent. (Koks *et al.* 2016) Besides these characteristics, there are several theoretical differences between the two models. IO models have short-term time horizons, and input substitutions are not possible (Koks *et al.* 2016). Mathematical complexity is usually linear and simple. On the contrary, CGE models can handle non-linearity and have substitution possibilities (Rose 1995). For sector interdependencies, IO models use technical coefficients but CGE models make use of cross elasticities. CGE analysis has the advantage of a strong price-quantity integration and a broader set of interactions than IO analysis, but has more restrictive assumptions. CGE models assume optimising behavior, so that the economy is in equilibrium (Rose 1995).

However, the fact that multiple markets must be considered simultaneously makes the model difficult and complex to use, particularly when analyzing the specific impact on each item in detail. The results of the analysis suffer highly from sensitivity from the assumptions made about the type of the utility and the production function, as well as the type of parameter values in use, such as elasticity (Burfisher 2016).

Although strong assumptions are used, the features of the CGE model described above make the model relatively more suitable for international and inter-regional competition analysis compared to the IO model. It is particularly well suited for analyzing welfare effects, because it quantifies the effects of shocks on all prices and quantities in an economy (Burfisher 2016). Moreover, it is also useful for tax policy analysis as it quantifies both tax revenues and excess burdens of taxes (Burfisher 2016). With these advantages, CGE models have been used as a standard tool for empirical economic research (Löfgren *et al.* 2002). Since early 1990, research on the trade effects and trade liberalization of the open economy has been actively conducted using the computable general equilibrium (Dixon & Jorgenson 2012). With the initial study by Scarf & Hansen (1973), Devarajan *et al.* (2018) and Bouet (2008) described the computational procedure of a CGE model in the case of trade liberalization in their book. Fugazza & Maur (2008) and Tarr (2012) introduce the effect of non-tariff and regulatory barriers using the CGE model in the trade policy analysis.

Most quantitative research conducting trade war analysis has adopted the general equilibrium model as an analytical method. Bolt *et al.* (2019) has used a multi-regional general equilibrium model to analyze the macroeconomic effect of the US-China trade war, focusing on the Eurozone area. When the US imposed unilateral tariffs on China, global output contracted, and when China retaliated, the situation worsened. However, the euro area has benefited to some extent due to the trade diversion effect. IMF (2018) has used a multi-regional dynamic stochastic general equilibrium model with world input-output tables, where four scenarios with different rates of tariff were simulated in the model: (i) the current tariff, (ii) an additional 10% tariff on US imports with retaliation, (iii) an additional 25% tariff on US imports with retaliation, and (iv) a confidence shock. The model was applied to six countries and regions: the US, Japan, the EU, emerging Asian countries including China, Latin America, and the rest of the world. According to the model estimation, both China and the United States had negative economic impacts in all scenarios, but the real GDP decrease was greater in China. Noland (2018) has adopted a social accounting matrix multiplier model to estimate the impact of the trade war on economic output and employment in the US. The results showed that 45% tariffs on imports by both countries lead to strong negative impacts on output and employment.

2.3 CGE Models and the US-China Trade War

Table 2.1: Recent US-China trade war researches using the GTAP model

	Time dimension	*GTAP Data*	*Scenario*	*Conclusion*
Balistreri & Rutherford (2018)	Static model	Base year 2014, 20 regions, 57 industries	Tariff escalation of the 2018 trade war	-0.20% welfare impact for the US and -0.34% for China
Cui *et al.* (2019)	Static model	Base year 2011, 11 regions, 17 industries	Six export reduction scenarios of both countries up to complete halt of trade	GDP declines up to -4.13% in China and -0.63% in the US
Itakura (2019)	Dynamic model	Base year 2011, 140 regions, 57 sectors.	1. raising import tariffs, 2. deterring foreign investment, 3. lowering productivity	Trade war reduces GDP in China y -1.41% and the US by -1.35%
Rosyadi & Widodo (2018)	Static model	Base year 2011, 29 regions, 20 industries	1. mutual 45% tariffs 2. mutual 45% tariffs for manufacturing commodities	US GDP falls by1.22% and China's by 5.4%.
Song & Lee (2018)	Static model and dynamic model	Base year 2014, 7 regions, 12 industries	1. US imposes 25% tariffs on China, 2. 25% mutual retaliation, 3: additional 25% tariffs on automobiles, steel.	GDP decreased up to0.33% in the US and 0.44% in China
Tsutsumi (2018)	Static model	Base year 2011, 16 regions, 12 industries.	Tariff action of 2018 trade war	0.1% GDP loss for the US and 0.2% GDP loss for China

Source: Authors

For analyzing large policy shocks in a global environment, a global general equilibrium modeling framework is required (Bollen & Rojas-Romagosa 2018). Numbers of scholars have adopted the CGE model to analyze the impact of the US-China trade war. Many of the researchers who adopted the CGE model used the GTAP model and database, which are employed in numerous countries and international organizations such as the WTO and the IMF to analyze the effect of trade policy (Walmsley & Minor 2018). As for the trade war, the US Department of Commerce (2018) used the GTAP model to evaluate the impact of tariffs in the steel Section 232 report. The studies that analyzed the US-China trade war using the GTAP model are summarized in Table 2.1.

As shown in Table 2.1, Balistreri & Rutherford (2018) has evaluated welfare impacts on the global economy using a static multi-region multi-sector general equilibrium simulation model. It is noteworthy that structural sensitivity analysis was performed on alternative trade assumptions. With simulations, Balistreri & Rutherford (2018) concluded that continued US and China tariff hikes would have a significant negative impact on consumer welfare throughout the global economy. Tsutsumi (2018) also employed a comparative static GTAP model to analyze the 2018 tariff action of the US-China trade war. Tsutsumi (2018) reported additionally imposed tariffs on goods decreased the GDP in China by 0.2% and the US by 0.1%. Moreover, considering technological spillover further lowered the GDP in China by 2.5% and in the US by 1.6%.

A static CGE model provides snapshots of economic changes before and after a shock, but does not describe the economy's adjustment path to the new equilibrium. However, a dynamic CGE model can trace a baseline time path and describe the difference between it and the time path accompanied by the economic shocks (Burfisher 2016). Song & Lee (2018) has used both static and dynamic GTAP CGE models to estimate changes in macroeconomic variables and imports and exports by industry in the United States and China. Three scenarios were considered in the study: (i) the United States imposes tariffs on China unilaterally, (ii) the United States and China imposes tariffs on both sides, (iii) the United States extends protectionism to another country. The research showed that in the event of a trade war, both GDP and welfare would be reduced. Among them, China's decline would be greater than that of the United States, and the trade war would be regarded as more disadvantageous to China than to the United States. The longer the trade war, the greater the decline in China's GDP and welfare. Bollen & Rojas-Romagosa (2018) has also employed the dynamic CGE model and further set up seven specific possible trade conflict scenarios. The results suggest that with unilateral US tariffs on steel and aluminum, there would be only minor negative impacts on both economies. However, with reciprocal tariffs and retaliations from China, GDP was reduced by 0.4% for the USA and 1.2% for China. With trade war escalation scenarios, real GDP losses were even higher. Similarly, Itakura (2019) has evaluated the impact of the trade war using a dynamic CGE model. The research concluded that the escalation of the trade war would lower GDP in China by 1.41% and in the US by 1.35%.

Cui *et al.* (2019), Li *et al.* (2018), and Rosyadi & Widodo (2018) have also used the static CGE model, but considered scenarios ranging up to a slightly more extreme trade war situation. Cui *et al.* (2019) proposed six sequential scenarios in which trade between the two countries declines and then ceases completely. As a result of the analysis, real GDP declined up to 4.13% in China and 0.63% in the US. Cui *et al.* (2019) concluded that the trade dispute is a lose-lose situation for both countries. Li *et al.* (2018) has considered four scenarios in which the US and China raise tariff levels to 15%, 30%, 45% and 60%. Using a multi-country global general equilibrium model, Li *et al.* (2018) reported similar results which showed the trade conflict would have negative impacts on both economies and lowered consumer welfare. However, the negative effects were more prominent in China than the US in the simulation. Using a static GTAP model, Rosyadi & Widodo (2018) has simulated a situation in which the US and China impose a mutual 45% tariff, and a situation where both countries impose a 45% tariff on manufacturing commodities only. As a result of the analysis, in the first scenario, the US's GDP decreased by 1.22% and China's by 5.4%. In the second scenario, the US showed a decrease in GDP of 0.98% and China 4.3%.

Some research has studied the effect of trade wars on the world economy accounting for the global value chain. Itakura (2019) modified the dynamic CGE model with agent-specific import demands in order to take into account the global value chain. Under their scenario, world GDP was reduced by $450 billion and the negative impact was more spread across countries. Mao & Görg (2020) has estimated the indirect impact of the trade war in third countries using the global value chain, and results suggest that increasing tariffs on US imports to China is more likely to hurt trade partners downstream of global supply chains, namely close trade partners such as Canada and Mexico. Walmsley & Minor (2018) adopted a recursive dynamic CGE model with a global value chain and estimated the impact of a trade war on third countries and regions such as Japan, Korea, India, Canada, Mexico, Russia, and the European Union. Results reported that the US GDP would be reduced by 1.78% in 2019 and by 1.25% in the long run. Except for the US and China, GDP increased in all countries with the trade war. Bellora & Fontagné (2019) computed value added changes and welfare impacts by tracking price changes in the general equilibrium, and the estimated results were consistent with other research papers.

Devarajan *et al.* (2018) has estimated the effects of increased tariffs on US imports from all regions to be 30% after retaliation by its trade partners. Unlike other research, Devarajan *et al.* (2018) has assumed counterfactual scenarios in terms of the response of developing countries: (i) join the trade war, (ii) do nothing, (iii) make regional trade agreements with non-US countries, or (iv) make regional trade agreements with non-US countries and fully liberalize imports from the US. The results suggest that joining the trade war is the worst option for developing countries, while joining the regional trade agreements and fully liberalizing imports is the best option.

Based on the literature, this study also employs a static GTAP model and a GTAP database. In order to take into account various economic decoupling situations, the scenario assumes three cases: a decrease in trade volume, an increase in tariffs, and a decrease in trade efficiency. See Chapter 4 for details on the scenarios and data.

Chapter 3

Overview of the US-China Trade War

In order to subject the impacts of the trade war between the US and China to an analysis, it is necessary to first understand this war's defining characteristics as well as the relevant historical trends. In this chapter, a brief overview is offered and the more important features of the US and China trade war are reviewed. In addition, observations on trends and changes in major macroeconomic variables through the trade war are presented.

3.1 Development of US-China Conflicts

Disputes over trade between the United States and China are not new. In 2007, the US submitted a complaint to the WTO against China's export subsidies and announced it was raising tariffs on glossy papers from China by 10-20% in order to offset the subsidies. This changed the direction of a policy that had not imposed countervailing duties on a non-market economy for twenty-three years. The Obama administration filed sixteen formal complaints at the WTO and initiated ninety-nine investigations on anti-dumping and countervailing duties. The US has continued to criticize China's unfair competition through WTO complaints and announcements. There were twenty-two complaints filed by the US as of 2018 and most of them involve China's export subsidies, which hurt fair competition in the US domestic market.

While these tensions and complaints in trade have continued to exist, the disputes were most often considered under the WTO until the Trump administration took office. The WTO was established to resolve trade disputes without causing trade wars, and the US has addressed issues such as China's subsidy policy, controls on the export of rare earths, and intellectual property rights violations through the WTO's dispute settlement body. The Obama administration had a strategy of resolving these problems through crafting multilateral trade agreements under the international system. The Trans-Pacific Partnership (TPP) was negotiated by the Obama administration with eleven countries in Asia and the Americas. It covers tariffs as well as definitions of state-owned enterprises, chapters on labour standards, and a section on currency manipulation. China was initially excluded, but the rules drafted by the US appear to take into account China's influence in Asia. The Trump administration announced the US withdrawal from the TPP in 2017. Before the trade war, trade disputes were dealt with within the existing normative framework, and there may have been some impact from signaling effects, though there were no abrupt shocks such as massive tariff hikes.

There are different opinions about what caused the trade war and how to interpret it. In 2017, when Trump issued a memorandum instructing the United States Trade Representative (USTR) to consider additional tariffs on Chinese goods, he offered several explanations: unfair trade practices, a continuously large trade deficit, the illegal transfer of American technology and intellectual property, and the diversion of American jobs to workers in China. Chong & Li (2019) categorized the driving forces of the trade war into three categories. First, ostensibly, was the widening trade gap between the United States and China. While it is true that the US trade deficit with China was growing both in relative and absolute terms, it alone does not account for the outburst of the entire trade war. Another driving force was political; an effort to secure votes in midterm elections. Finally, Chong & Li (2019) noted that a battle for global economic dominance lies at the heart of the US-China trade war. Some scholars agree that the trade war is more than just a matter of trade and has the character of competing for future hegemony. Chen *et al.* (2019) analyzed the measures taken by the United States for the Belt and Road Initiative and Made in China 2025, which are China's representative "Chinese dream" programs, and argued that the real intention of the trade war has been preserving a preeminent position in the global economy. Song & Lee (2018) also took the view that at the political and economic core of the US-China trade dispute is the issue of whether China's industrial policies, such as Made in China 2025, can be harmonized with the long-term sustainability of the world trade order.

The prelude to the trade war came in April 2017 when President Trump issued a Presidential Memorandum initiating a Section 232 investigation into steel and aluminum imports. Trump then successively introduced various forms of trade sanctions including administrative orders, trade regulations, and safeguards, targeting Chinese washing machines and solar panels to reduce the US trade deficit with China. There have been four rounds of tariff hikes between the United States and China since the full-scale trade war began in July 2018. A detailed timeline of the trade war can be found in Table 3.1.

The first round of the war refers to the exchange of 25% tariff increases on $34 billion worth of commodities on July 6, 2018. The Chinese goods which were subject to the sanctions in the US were mainly electronic components, home appliances, electronic devices, and machinery. The sanctions which were placed upon the US by China targeted key US sectors, including soybeans and pork products, steel, automobiles and aircraft. The second round refers to a 25% tariff increase in August 2018 for goods worth $16 billion. The United States imposed additional tariffs on goods such as Chinese clothes, refrigerators, televisions, cosmetics, and foods. On September 24, 2018, the US imposed a $200 billion, 10% additional tariff on 5,745 Chinese imports in the third round. On the same day, China retaliated with a 10% counter tariff on a total of 5,207 American goods worth $60 billion dollars. Finally, in the fourth round on September 1, 2019 the US imposed a tariff on $125 billion of Chinese imports and China imposed additional tariffs on $75 billion of US exports. After the fourth round, both countries introduced exemption lists, and since then some of the tariff increases which were announced have been rolled back.

On January 15, 2020, about three years after the war began, the United States and China signed the Phase One agreement in Washington. The two countries agreed to trim some tariffs and China agreed to buy $200 billion worth of American agricultural products, manufactured goods, and energy products and services from the United States over 2020 and 2021. Exact figures were not disclosed, but the amount of U.S. agricultural products that China agreed to purchase was targeted at at least $40 billion, a rise from $24 billion in 2017. However, according to the recent calculations of Bown (2021), US goods pur-

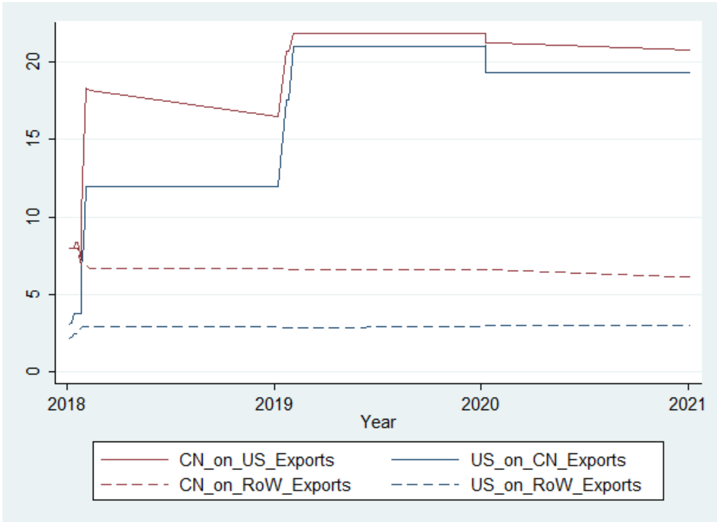
Table 3.1: US-China trade war timeline

	US Action	*China Response*
2017 20-Apr	President Donald Trump initiates a section 232 investigation on steel imports	
27-Apr	President Donald Trump initiates a section 232 investigation on aluminum imports	
17-Aug	The USTR initiates a 301 investigation on China	
2018 22-Jan	First trade action against China comes with tariffs on imported solar panels and washing machines.	
08-Mar	US announces a 25% tariff on steel imports and 10% on aluminium imports	
23-Mar		China proposed tariffs on US goods to be effective from 2 April 2018 ($3 billion)
02-Apr		15-25% tariffs on 128 products ($3 billion)
15-Jun	Initial tariff list revised : 25% tariff on reduced 818 products. Second list of tariff on 284 products	
16-Jun		Initial tariff list revised : 25% on increased 545 products ($34 billion). 25% tariff on list 2 of new 114 products ($16 billion)
	First round	
06-Jul	List 1 : US imposing a 25% tariff of Chinese goods takes effect ($34 billion)	List 1 : China imposed 25% tariff on US goods takes effect ($34 billion)
	Second round	
23-Aug	List 2 : US imposing 25% tariff of Chinese goods takes effect ($16 billion)	List 2 : China imposed 25% tariff on US goods takes effect ($16 billion)
27-Sep	List 3 tariff finalised : ($200 billion) Effective on September 24 at 10%to be increased to 25% by Jan 1 2019	
	Third round	
24-Sep	List3 : US imposes 10% tariff on $200 billion of Chinese goods, and will increase to 25% by Jan. 2019	List 3 : China levies 5-10% tariff on $60 billion worth of US goods(5207 products) (list published on August 3)
02-Dec	US and China agree to temporary truce for 90 days(until March 1, 2019)	Agrees to a temporary truce for 90 days until March 1, 2019
14-Dec		Temporarily remove 25% tariffs on US autos and 5% tariffs on certain US auto parts
2019 01-Jan		Removes 25% tariffs on US autos and 5% tariffs on certain US auto parts for three months
10-May	Tariffs on list 3 products increases from 10% to 25%($200 billion)	
01-Jun		Tariffs increased on $60 billion worth of products. 10%->25%; 10%->20%; 5%->10% and 5%
09-Jul	100 Chinese products exempted from 25% tariffs, valid for a year	
01-Aug	10% tariff on list 4A products ($300 billion). 25% tariff on list 4B products ($250 billion) depending on condition	
23-Aug	Tariffs on list 4A increased; tariffs on list 4B products increased from 25% to 30%	5% and 10% tariffs on 5078 goods. ($75 billion) US automotive (5%) and auto parts(25%) tariffs reinstated from Dec 15.
	Fourth round	
01-Sep	15% tariffs on list4A products ($125 billion)	5% and 10% tariffs on 5078 products ($75 billion)
13-Sep		Tariff on various agricultural products exempted. Exemption valid for a year
11-Oct	Phase One deal; tariff increase on list 4B (scheduled Oct 15) postponed	Phase One deal; agrees to purchase $40-50 billion US agricultural products annually
13-Oct	Tariff on some products on list 4A exempted. Exemption valid till Jan 31 2020.	
13-Dec	List 4A tariff reduced from 15% to 7.5%.	Agrees to increase the purchase of US goods and services by at least $200 billion over the next two years. Second set of US products exemption list released.
	Phase One deal	
2020 15-Jan	Signs Phase One deal: China agrees to purchase an additional $200 billion worth of US exports; most tariffs remain in effect. China does not address subsidies or state-owned enterprises.	Signs Phase One deal: China agrees to purchase an additional $200 billion worth of US exports; most tariffs remain in effect. China does not address subsidies or state-owned enterprises.
14-Feb	Phase One deal goes into effect.	Phase One deal goes into effect.
04-Dec		China's Phase One deal purchases are falling short.

Source: Ministry of Finance of the People's Republic of China.
Office of the United States Trade Representative

chased by China in 2020 not only fell short of Phase One commitments, but were also lower than in 2017, before the trade war.

Figure 3.1: Chinese and the US average tariff on exports from 2018 to 2021



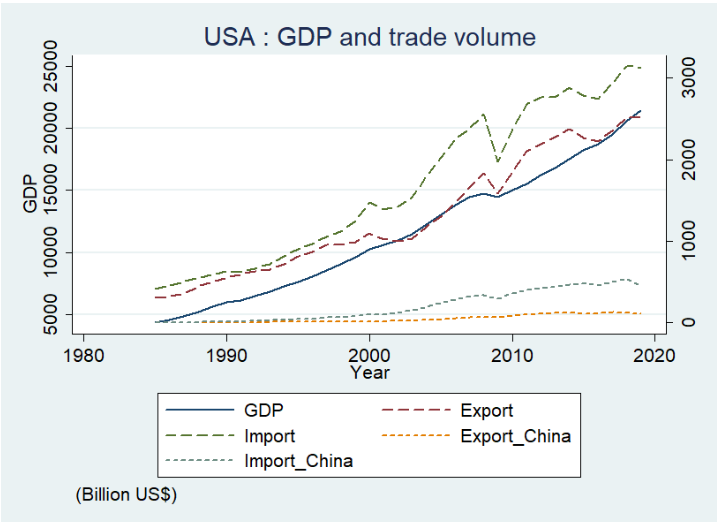
Source: Data collected from Market access map, China's ministry of Finance, USTR and calculated by Bown (2021)

Figure 3.1 shows how the average tariff rate between the US and China changed as the trade war progressed. The average tariff data were collected from the Market Access Map, USTR, and China's Ministry of Finance and calculated by Bown (2021) weighted by exports to the rest of the world. The solid red line shows the average tariffs imposed by China on U.S. exports, and the dotted red line shows the average tariffs imposed by China on rest of the world exports. Additionally, the solid blue line is the tariff the US has levied on Chinese exports, and the blue dotted line is the tariff the US has levied on the world's exports. As of January 1, 2018, China's average tariffs on the US were 8%, but as the trade war progressed, it increased to a maximum of 22%, and then receded to 20.7% as of January 1, 2021. On the other hand, the average US tariff on China started at 3.1% in 2018, increased to 21% in 2019, and reached 19.3% in 2021. These increased tariffs are applied to more than half of all exports. As of January 1, 2021, China's exports affected by increased tariffs due to the trade war accounted for 58.3% of its total exports, and US exports affected reached 66.4%.

It is noteworthy that since the start of the trade war, the average global rate of US tariffs excluding China has increased from 2.2% to 3%, while the average tariff China imposes on the rest of the world has decreased from 8% to 6.1%. Since the beginning of the trade war, China has continuously cut the Most Favored Nation (MFN) tariff, which has been applied to hundreds of products, including consumer goods, automobiles, information technology products, and pharmaceutical products. Moreover the Chinese government has announced that it will further cut tariffs in the future. This is presumed to be a way to replace US imports, which have been reduced due to increased tariffs. In addition, it can be inferred that demand in the Chinese domestic market has increased as the government continuously reduces tariffs. These measures will lower the production costs of Chinese manufacturing and may increase the international competitiveness of Chinese manufacturing.

3.2 Trends in Trade

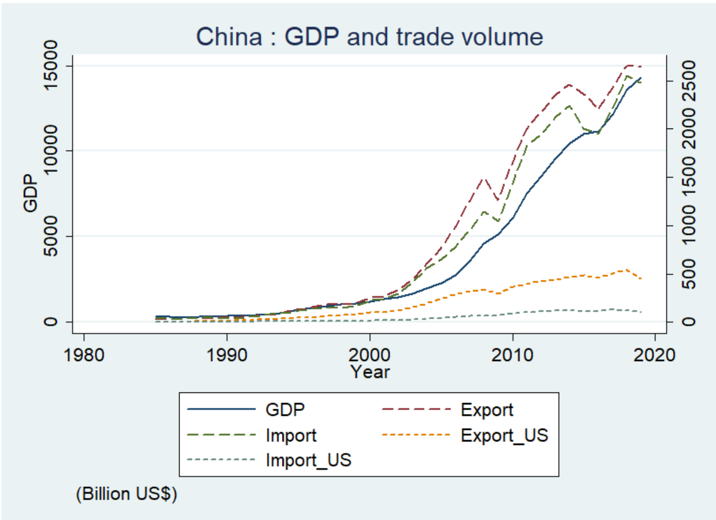
Figure 3.2: USA GDP, trade, and bilateral trade volume 1985 to 2019



Source: World Bank, US Census Bureau

As a key currency country, the United States has sustained a merchandise trade deficit for decades. As shown in Figure 3.2, US GDP, exports, and imports are steadily increasing over time. Because imports far outweigh exports, the United States continues to run a trade deficit both with the world and with China. In 2019, the United States exported $1.65 trillion worth of goods and imported $2.52 trillion worth of goods. Merchandise trade deficit was $864 billion and service trade surplus was $287 billion at that time. In China, however, macroeconomic indicators have grown rapidly since 2000, as shown in Figure 3.3. Since 2000, China's exports have continued to increase, and the United States has been the largest importer of Chinese goods. Product trade between the United States and China increased about 33 times from $20 billion in 1990 to $659 billion in 2018. In 2018, the total trade deficit of the US was $870 billion, of which the trade deficit with China was $419 billion. The share of the US's trade deficit of merchandise against China has steadily increased every year since 2000, reaching 48% in 2018 and decreasing to 45% in 2019. However, the United States has been recording the trade surplus in services since 1990. The service trade balance in the United States has grown to $74 billion in 2000, $153.4 billion in 2009, and $287 billion in 2019.

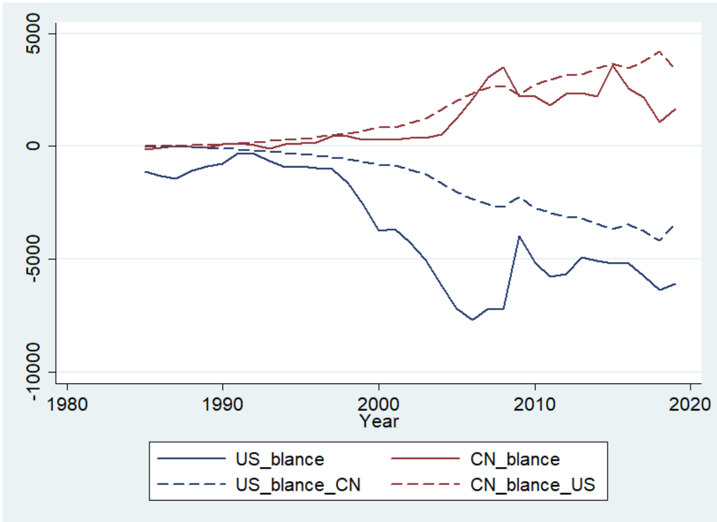
Figure 3.3: Chinese GDP, trade, and bilateral trade volume 1985 to 2019



Source: World Bank, US Census Bureau

At first glance, the US trade deficit with China seems enormous. Based on these figures, the Trump government has defined the trade policy before the trade war as ”unfair trade” and a ”bad trade agreement”. He has pointed out that a consistently high trade deficit with China could be the cause of declines in employment and economic growth. However, to verify this claim, not only trade in goods, but also trade in services and global value chains should be considered. The United States has been recording the trade surplus in services since 1990. The service trade balance in the United States has grown to $74 billion in 2000, \$153.4 billion in 2009, and \$270.2 billion in 2018.

Figure 3.4: US-China total trade balance and bilateral trade balance 1985 to 2019

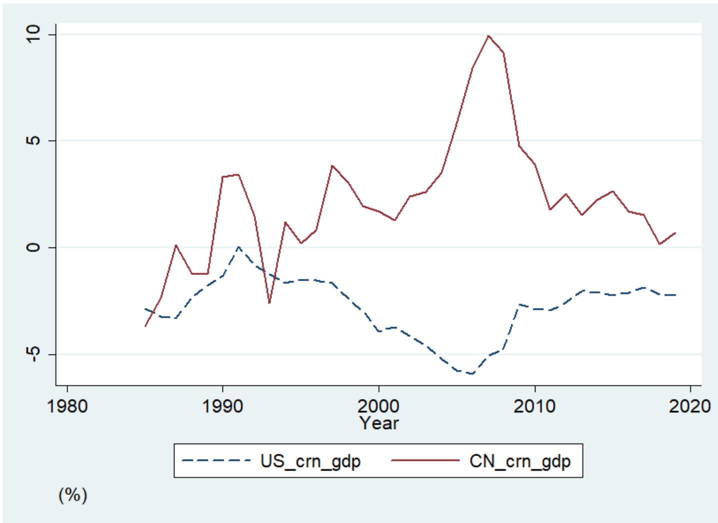


Source: World Bank, US Census Bureau

Eugster *et al.* (2018) stated that targeting only a particular subset of a bilateral trade balance will only lead to trade diversion or offsetting changes in the trade balance with other trade partners unless the macroeconomic conditions are properly addressed. China's large trade surplus with the US alone cannot be sufficient evidence of China's causing the US economic growth slowdown nor of the currency manipulation allegations by China that the US has raised. Instead, China's trade surplus with the US largely reflects changes in the supply chain in Asia. Much of what the US imports from China has previously been imported from Japan, South Korea, and Taiwan. As the global supply chain develops, specializations of countries across and within sectors have deepened (Eugster *et al.* 2018). In 1995, Japan served as the Asian factory hub, but China is now taking on that role. In the past, goods manufactured by Japanese companies were exported directly to the United States, but now components produced in Asia are first shipped to China for the assembly process and finished goods are then exported to the United States.

Due to the complex global value chain, net exports do not properly reflect the status of trade between the two countries. Factors such as value-added in trade, corporate ownership, and gross sales should be taken into account as well as net exports. A typical example of the GVC can be seen in Apple's iPhone. As of 2019, Apple had approximately 200 suppliers in over 800 production facilities around the world. The iPhone's conception and design occur in California, but the major high-tech parts are made all over the world, such as in Japan, Korea and Germany, and the final assembly process takes place in China. Xing & Detert (2010) has estimated that about 96.4% of the income that China receives from the US for exporting iPhones was transferred to other countries involved in the production chain, including Germany, Japan, Korea, and the US. Among industries with intensive global supply chains, electrical machinery and equipment, automobiles, and clothing account for a large proportion of China's exports.

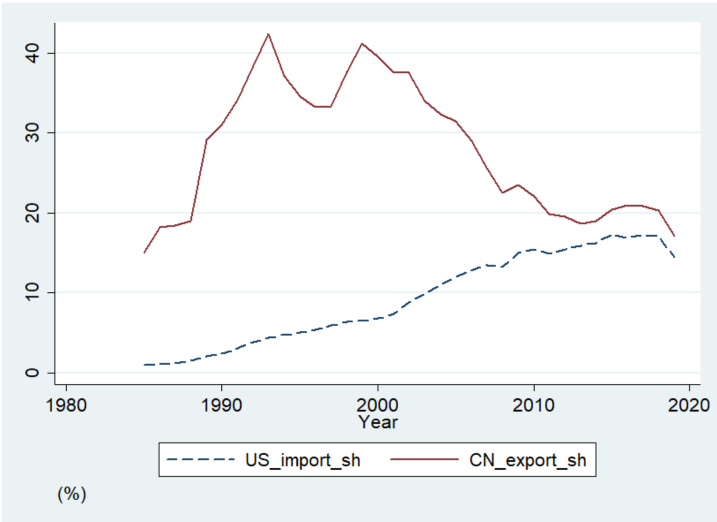
Figure 3.5: Current account balance to GDP in the US and China 1985 to 2019



Source: World Bank

Figure 3.4 depicts the total trade balance and bilateral trade balance between the US and China. The red solid line and the red dashed line represent China's trade balance, and it can be seen that the trade surplus shows an upward trend. On the other hand, the data for the US, indicated by the solid blue line and the blue dashed line, shows a continuing trend of trade deficits. To analyze the actual imbalance, a current account balance must also be considered. To better understand the economic impact, Figure 3.5 shows the current account balance of the US and China as a percentage of GDP. While China's overall current account surplus is large, the US has recorded a current account deficit of about 4% of GDP over the past decade. This means the US continues import surplus savings every year from abroad by running a current account deficit; that is to say, the US spends more than it saves. Liu & Woo (2018) remarked that this overspending and inadequate saving behavior of the US economy is structural in nature rather than cyclical. China's excess savings also contribute to the trade imbalance.

Figure 3.6: Bilateral trade dependency of the US (imports) and China (exports) 1985 to 2019



Source: World Bank, US Census Bureau

Figure 3.6 demonstrates the bilateral trade dependency of US imports and Chinese exports. The upper solid line represents China's trade dependency on exports to the US, while the dashed line on the bottom represents the US trade dependency on imports from China. It is shown that the share of imports from China is increasing gradually in the US. However, China's international export dependency on the US has been undergoing a declining trend since 2000. This means the importance of the US trade in China's trade portfolio has fallen over the last twenty years. It is worth noting that while the United States' dependency on imports from China is increasing over time, China's dependency on exports to the US has been on a downward trend since before the trade war began.

China's dependency is decreasing not just in respect to trade with the United States but in total numbers as well. China's share of the total exports of goods and services to GDP has also been decreasing for the last two decades, possibly in part because of changes in its supply chain. This means that China has become a more closed economy.

3.3 Changes in Trade

Changes in trade between the two countries from the beginning of the conflict can be identified from various angles. First, the growth rate of exports and imports is changing. Compared to 2017, before the start of the trade war, U.S. goods exports increased 7.7% in 2018 and imports increased by 8.6%, according to the UN Comtrade Database. On the other hand, China's exports increased by 9.8% in 2018 compared to the previous year, but imports increased by 16%. In 2019, both indicators show signs of slowing: U.S. exports fell 1.2% and imports fell 1.7%, while China's imports fell 3.1% and exports rose 0.2%. The impact of the trade war was evident in the shift in trading volume between the US and China, as U.S. imports from China increased by 7.1% in 2018, but declined sharply by 16.1% in 2019. China's imports of goods from the United States increased 0.8% in 2018 and then fell sharply to 21% in 2019.

Table 3.2: USA top 10 import commodities 2017 to 2019

HS Code	*4-digit heading of Harmonized System 2012*	*Value(billion US$)*					
		2017		*2018*		*2019*	
8703	Motor cars and other motor vehicles principally designed for the transport	179.6	(7.5%)	178.5	(6.8%)	179.5	(7.0%)
2709	Petroleum oils and oils obtained from bituminous minerals; crude	139.3	(5.8%)	162.8	(6.2%)	132.4	(5.2%)
8517	Electrical apparatus for line telephony or line telegraphy	113.3	(4.7%)	111.2	(4.3%)	101.9	(4.0%)
9999	Commodities not specified according to kind	91.0	(3.8%)	101.5	(3.9%)	113.2	(4.4%)
8471	Automatic data processing machines and units thereof	84.8	(3.5%)	93.6	(3.6%)	91.1	(3.5%)
3004	Medicaments	65.0	(2.7%)	71.6	(2.7%)	78.9	(3.1%)
8708	Parts and accessories of the motor vehicles	66.3	(2.8%)	71.4	(2.7%)	69.9	(2.7%)
2710	Petroleum oils, other than crude	48.1	(2.0%)	61.5	(2.4%)	61.9	(2.4%)
3002	Human blood; animal blood prepared for therapeutic uses	26.4	(1.1%)	37.1	(1.4%)	42.9	(1.7%)
8542	Electronic integrated circuits	33.5	(1.4%)	34.8	(1.3%)	33.1	(1.3%)
	Others	1558.0	(64.8%)	1687.4	(64.6%)	1662.7	(64.8%)
	All Commodities	2405.3	(100%)	2611.4	(100%)	2567.5	(100%)

Source: UN Comtrade Database

The aftermath of the trade war is reflected in the share of both traded commodities and trade partners. Table 3.2 shows the major items of import in the United States. At the top of the list are machinery and transport equipment, and when chemical products are included, these categories account for more than half of the total imports. The top imported commodities were motor cars and other motor vehicles for transport. The value of the item imports decreased from $179.6 billion to $178.5 billion in 2018, and their share in total imports decreased from 7.5% to 6.8% as well.

Table 3.3: USA top 10 export commodities 2017 to 2019

HS Code	*4-digit heading of Harmonized System 2012*	*Value(billion US$)* *2017*		*2018*		*2019*	
9999	Commodities not specified according to kind	163.4	(10.6%)	176.9	(10.6%)	173.9	(10.6%)
2710	Petroleum oils, other than crude	78.0	(5.0%)	95.9	(5.8%)	87.5	(5.3%)
8703	Motor cars and other motor vehicles principally designed for the transport	53.6	(3.5%)	51.4	(3.1%)	56.2	(3.4%)
2709	Petroleum oils and oils obtained from bituminous minerals; crude	22.5	(1.5%)	48.3	(2.9%)	65.3	(4.0%)
8708	Parts and accessories of the motor vehicles	45.2	(2.9%)	45.7	(2.7%)	43.0	(2.6%)
8542	Electronic integrated circuits	38.0	(2.5%)	37.7	(2.3%)	40.1	(2.4%)
8517	Electrical apparatus for line telephony or line telegraphy	34.0	(2.2%)	32.4	(1.9%)	30.7	(1.9%)
9018	Instruments and appliances used in medical, surgical, dental or veterinary	26.6	(1.7%)	28.6	(1.7%)	29.7	(1.8%)
2711	Petroleum gases and other gaseous hydrocarbons	22.5	(1.5%)	28.2	(1.7%)	30.5	(1.9%)
8471	Automatic data processing machines and units thereo	25.4	(1.6%)	26.7	(1.6%)	25.8	(1.6%)
	Others	1036.6	(67.1%)	1093.5	(65.7%)	1061.6	(64.6%)
	All Commodities	1545.8	(100%)	1665.3	(100%)	1644.3	(100%)

Source: UN Comtrade Database

Changes in the United States' export commodities can be found in Table 3.3. The main exports of the US are machinery and transport equipment, chemicals and mineral fuels. Although there have been no significant change in export items during the trade war, it can be seen that exports in 2019 decreased compared to 2018.

Table 3.4: USA top 10 trade partner 2017 to 2019

Country	*Value(billion US$)* *2017*		*2018*		*2019*	
China	655.5	(16.6%)	683.3	(16.0%)	579.0	(13.7%)
Canada	588.0	(14.9%)	625.4	(14.6%)	618.9	(14.7%)
Mexico	559.2	(14.2%)	614.6	(14.4%)	617.7	(14.7%)
Japan	207.3	(5.2%)	221.1	(5.2%)	221.6	(5.3%)
Germany	173.5	(4.4%)	185.6	(4.3%)	189.7	(4.5%)
Korea, Rep.	121.7	(3.1%)	132.7	(3.1%)	136.8	(3.2%)
United Kingdom	110.4	(2.8%)	128.0	(3.0%)	133.2	(3.2%)
France	84.3	(2.1%)	91.2	(2.1%)	97.2	(2.3%)
India	76.2	(1.9%)	89.9	(2.1%)	94.3	(2.2%)
Italy	69.7	(1.8%)	79.0	(1.8%)	82.5	(2.0%)

Source: United States Census Bureau

Table 3.4 shows the top ten trade partners of the US from 2017 to 2019. The US' top three trading partners are China, Canada and Mexico. Until 2018, China was the largest trade partner of the United States. However, following the 2019 developments in the trade war, China is no longer America's largest trading partner. Trade statistics from 2019 show Canada has taken over the first place position, with Mexico in second place and China now down in third place.

Table 3.5: China top 10 export commodities 2017 to 2019

HS Code	*4-digit heading of Harmonized System 2012*	*Value(billion US$)*					
		2017		*2018*		*2019*	
8517	Electrical apparatus for line telephony or line telegraphy	219.2	(9.7%)	240.4	(9.6%)	224.1	(9.0%)
8471	Automatic data processing machines and units thereof	142.0	(6.3%)	154.2	(6.2%)	148.4	(5.9%)
8542	Electronic integrated circuits	67.2	(3.0%)	84.7	(3.4%)	102.2	(4.1%)
8473	Parts and accessories for use with machines	34.0	(1.5%)	45.3	(1.8%)	32.4	(1.3%)
8708	Parts and accessories of the motor vehicles	31.0	(1.4%)	34.8	(1.4%)	33.6	(1.3%)
8528	Peception apparatus for television	31.5	(1.4%)	33.4	(1.3%)	31.2	(1.2%)
9405	Lamps and lighting fittings	28.5	(1.3%)	30.6	(1.2%)	33.1	(1.3%)
9013	Liquid crystal devices	28.5	(1.3%)	25.7	(1.0%)	23.8	(1.0%)
8541	Diodes, transistors and similar semiconductor devices	26.6	(1.2%)	29.1	(1.2%)	34.6	(1.4%)
2710	Petroleum oils, other than crude	25.5	(1.1%)	35.8	(1.4%)	38.3	(1.5%)
	Others	1629.4	(72.0%)	1780.2	(71.4%)	1796.9	(71.9%)
	All Commodities	2263.4	(100%)	2494.2	(100%)	2498.6	(100%)

Source: UN Comtrade Database

Table 3.5 shows the major export items in China from 2017 to 2019. China's main export items are machinery and transport equipment and miscellaneous manufactured articles, which together account for nearly 70% of the total export items. The most exported item for the three years from 2017 through 2019 was electrical equipment. Compared to 2017, in 2019 its proportion of total exports decreased, but the exported amount increased. China's exports are concentrated in manufacturing, and total exports continued to grow despite the trade war.

Table 3.6: China top 10 import commodities 2017 to 2019

HS Code	*4-digit heading of Harmonized System 2012*	*Value(billion US$)*					
		2017		*2018*		*2019*	
8542	Electronic integrated circuits	261.2	(14.2%)	312.7	(14.6%)	305.8	(14.8%)
2709	Petroleum oils and oils obtained from bituminous minerals, crude	163.8	(8.9%)	239.2	(11.2%)	238.7	(11.5%)
2601	Iron ores and concentrates, including roasted iron pyrites	76.5	(4.1%)	75.0	(3.5%)	99.8	(4.8%)
7108	Gold (including gold plated with platinum)	51.4	(2.8%)	45.8	(2.1%)	44.0	(2.1%)
8703	Motor cars and other motor vehicles principally designed for the transport	49.9	(2.7%)	49.6	(2.3%)	47.0	(2.3%)
8517	Electrical apparatus for line telephony or line telegrapty	47.8	(2.6%)	48.9	(2.3%)	42.6	(2.1%)
1201	Soya beans, whether or not broken	39.6	(2.1%)	38.1	(1.8%)	35.4	(1.7%)
9013	Liquid crystal devices	37.3	(2.0%)	33.8	(1.6%)	28.1	(1.4%)
2711	Petroleum gases and other gaseous hydrocarbons	33.0	(1.8%)	50.0	(2.3%)	52.4	(2.5%)
8541	Diodes, transistors and similar semiconductor devices	28.2	(1.5%)	28.5	(1.3%)	26.1	(1.3%)
	Others	1055.1	(57.2%)	1213.4	(56.8%)	1150.1	(55.6%)
	All Commodities	1843.8	(100%)	2135.0	(100%)	2070.0	(100%)

Source: UN Comtrade Database

Changes in China's import commodities can be found in Table 3.6. China's main imports are machinery and transport equipment, mineral fuels and crude materials. The most imported item from 2017 to 2019 was electronic integrated circuits, and it can be seen that their import was particularly high in 2018. China's imports increased substantially in 2018, but declined in 2019 compared to the previous year.

Finally, Table 3.7 shows the share of China's major trade partners from 2017 to 2019. China's top three trading partners are the United States, Japan and Hong Kong. Excluding Hong Kong, Korea had the third highest proportion. Despite the trade war, the United States is still China's largest export destination. However, as the trade war progressed, the U.S. share of total trade fell from 14.2% in 2017 to 11.9% in 2019.

Table 3.7: China top 10 trade partner 2017 to 2019

Country	*Value(billion US$)*					
	2017		*2018*		*2019*	
United States	584.8	(14.2%)	635.7	(13.7%)	541.8	(11.9%)
Japan	303.0	(7.4%)	327.6	(7.1%)	314.7	(6.9%)
Hong Kong, China	286.5	(7.0%)	311.5	(6.7%)	288.7	(6.3%)
Korea, Rep.	280.3	(6.8%)	313.6	(6.8%)	284.5	(6.2%)
Germany	168.1	(4.1%)	184.2	(4.0%)	184.7	(4.0%)
Australia	136.4	(3.3%)	152.6	(3.3%)	167.7	(3.7%)
Vietnam	122.0	(3.0%)	148.1	(3.2%)	162.1	(3.5%)
Malaysia	96.1	(2.3%)	109.2	(2.4%)	124.1	(2.7%)
Brazil	87.8	(2.1%)	110.9	(2.4%)	114.7	(2.5%)
India	84.3	(2.1%)	95.7	(2.1%)	92.9	(2.0%)

Source: General Administration of Customs People's Republic of China

Chapter 4

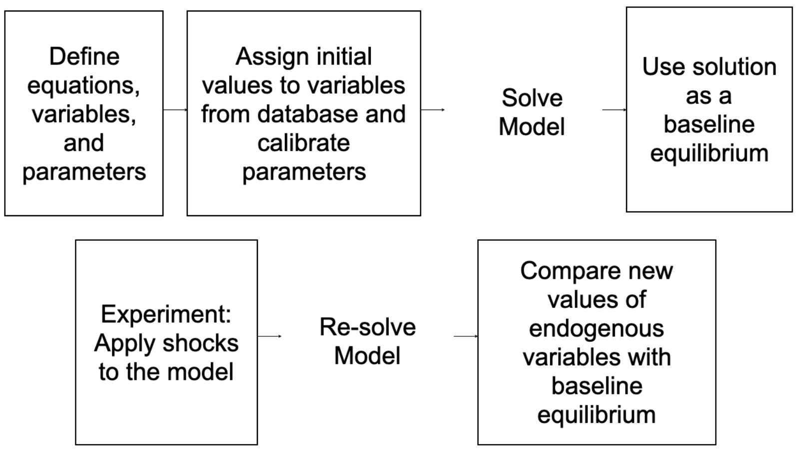
Empirical Model

This paper employs a CGE model for the empirical analysis. A Computable General Equilibrium model is a system of equations which illustrates an economy as a whole and the interactions among each part of the economy. It encompasses changes in all factors, regions, and sectors. The basic features of the model are well described through the components of its name. The model is "computable" in that it can quantify the impact of a shock on the economy, and it is "general" in that it considers all economic activities as well as their linkages simultaneously. These linkages result in a circular flow of income and spending. The model assumes that an economy is in "equilibrium" when supply and demand are in balance and no further changes occur.

General equilibrium models are meaningful in analyzing the effects of endogenous variables of models such as price, production, export, welfare, etc. The model simulations make it possible to predict how trade and production patterns may change when a shock or policy change is introduced, because the differences in the values of endogenous variables of baselines and simulations indicate the effects of changed policy. In a situation where several countries and markets are involved, a change in tariffs will result in a change in all countries and markets. Because the general equilibrium models take into account interaction across markets, the general equilibrium model is evaluated as ideal for analyzing multilateral trade liberalization policies (Bacchetta *et al.* 2012).

The CGE model consists of three main elements: the system of equations describing the general equilibrium model, the Social Accounting Matrix (SAM) and exogenous parameters (Bollen & Rojas-Romagosa 2018). The SAM comprises National Income and Product Account (NIPA) data and multi-region and multi-sector input-output tables, which are interconnected with trade data. The exogenous parameters consist of important information such as tax and tariff rates and the elasticities of supply and demand (Burfisher 2016).

Figure 4.1: CGE model structure and experiment design



Source: Burfisher (2016)

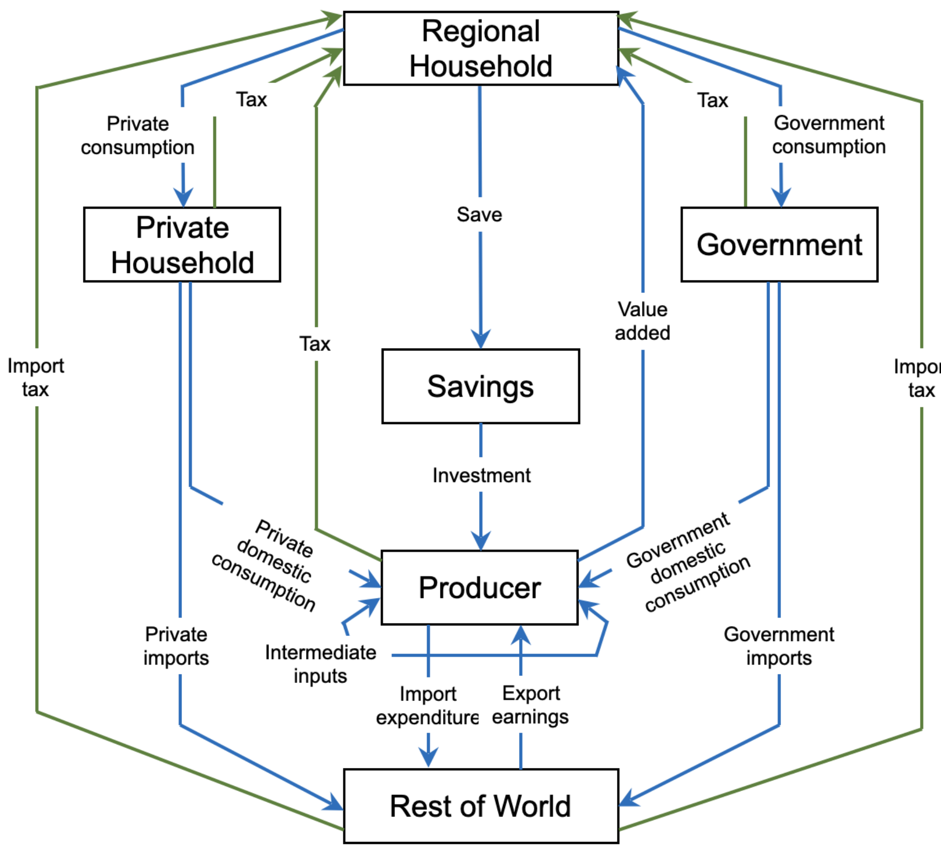
The analysis using the CGE model roughly follows the following procedure. First, the modeler defines sets, equations, variables, and parameters for the model. By assigning initial values to variables from the database and elasticity parameters, the model enables the calibration of the shift and share coefficients used in supply and demand equations (Burfisher 2016). Using these, the model is solved, and its solution can be used as a baseline equilibrium.

The modeler can conduct experiments by changing an exogenous variable or parameter in the model. When a shock is administered to the model, for example an increase in tariffs, the shock causes changes in the economy and disturbs the original equilibrium. Accordingly, all the model equations are solved again to find new solutions. This new solution becomes the new economy-wide equilibrium. Naturally, the model enables comparisons of efficient resource allocation before and after the shock. This analytical procedure of the CGE model is depicted in Figure 4.1.

CGE models are standard tools to assess trade policy changes, and are widely used by international organizations (Bollen & Rojas-Romagosa 2018).

As discussed in the literature review in Chapter 2, many researchers have adopted the CGE model when analyzing trade disputes. Rosyadi & Widodo (2018) has noted that CGE analysis appears to be superior to partial equilibrium analysis as it provides an economy-wide evaluation instead of an isolated analysis of a particular sector. Specifically, Hertel *et al.* (2007) has remarked that the CGE model is more significant in its ability to capture economic interactions of bilateral trade flow and policy change effects in a multi-country and multi-sectoral context. The characteristics of this model are suitable for the purposes of this study, as the economic influence of the United States and China is felt worldwide.

Figure 4.2: Flow chart of the GTAP model



Source: Corong *et al.* (2017)

Implementing a CGE model from scratch is not necessarily an easy task (Bacchetta *et al.* 2012). First, it requires the modeler to collect a vast amount of data sets and then assemble them. The required data will vary depending on the purpose of the study, but collecting individual input-output tables of most countries in the global economy and reconciling the proper structure is typically time-consuming work. In addition, a balanced social accounting matrix should be built. Appropriate data from different sources such as tariffs and taxes for each country should be collected and balanced together. After all data processing is finished, it is crucial to specify the proper model. With a system of equations expressing the economic theories used in the model, such as linkages in the economy or circular flow, it is usually necessary to write coding to solve the formulas. Because of these characteristics, many CGE modelers use an analysis software rather than build a model from scratch.

This research utilizes the Global Trade Analysis Project (GTAP) CGE model, developed by Thomas Hertel and colleagues at Purdue University. Details of the model are fully documented in Hertel (1997). The GTAP not only provides the modeling framework but also offers necessary software for manipulating the data and implementing the model (Hertel 1997). It is a powerful tool that many CGE modelers rely on, and has a consistent global database built from data contributions by its users around the world (Burfisher 2016). It features extensive coverage, from the dimensionally large input-output tables to the detailed trade and investment database (Van Ha *et al.* 2017). GTAP is used in many economic fields of study, but it is particularly popular with scholars studying the effects of trade policies such as free trade agreements. GTAP is also widely used by governments and international organizations. In 2019, the WTO developed and announced the WTO Global Trade Model, which is an extension of the standard GTAP model (Aguiar *et al.* 2019). The GTAP model was also employed when the US government investigated the impacts of tariffs on steel imports at the beginning of the current trade war with China (US Department of Commerce 2018). For these reasons, the GTAP CGE model is deemed to be an efficient and effective tool for answering the questions of this study.

The standard GTAP model is a multi-region, multi-sector CGE model with perfect competition, constant returns to scale, and product differentiation by origin, i.e. the Armington assumption, the theoretical structure derived from optimizing behavior by agents. Households maximize their utility subject to budget constraints through private consumption, which is characterized by a non-homothetic constant difference of elasticity (CDE). Firms produce commodities by combining intermediate inputs and primary factors, such as land, labor, capital, and natural resources. The intermediate inputs are determined by a fixed proportion to output and are composed of domestic supply and aggregate imports. The regional household account collects all sources of income and distributes them for private consumption, public expenditures and savings using the Cobb-Douglas utility function. Savings are translated into investment spending for the producer. The production structure is based on a sequence of nested constant elasticity of substitution (CES) functions. Government consumption is assumed to follow the CES function as well (Corong *et al.* 2017). The main structure of the model is depicted in Figure 4.2.

This study follows the standard GTAP model's macroeconomic closure. The endowment of factors is fixed and the factor's real price varies. Government expenditures and private consumption are treated as exogenous. The endogenous domestic production level varies to maintain a fixed export subsidy. Likewise, an endogenous import quantity maintains fixed import tariffs. However, in Scenarios 3 and 4, tariffs are swapped to be endogenous. Details are described in Section 4.1. Gragg's extrapolation method was used to solve the model, as it reduces possible distortions in the linear method of Johansen and Euler, and allows the modeler to specify the steps for more accurate calculation (Hertel 1997). Specifically, a Gragg: 2-4-6 steps extrapolation was used for the model solution. A more detailed explanation of the model and the data of the GTAP can be found on the official GTAP website [1] and in Corong *et al.* (2017).

There are few essential elasticity parameters in the model. *SUBPAR* is a parameter related to compensated own and cross price elasticities of substitution and *INCPAR* is a parameter related to the income elasticity of demand. These parameters are only relevant for a private household's utility function. Larger *INCPAR* values imply larger income elasticities of demand and larger *SUBPAR* values imply larger compensated own price elasticities. The value of *INCPAR* and *SUBPAR* varies according to region and sector. The calibrated values are given in Table A.1 and Table A.2 in Appendix A.

The importance of Armington elasticities (*ESUBD* and *ESUBM*) for CGE modeling of trade policy is indisputable (Mcdaniel & Balistreri 2002). *ESUBD* is a substitution parameter between domestic goods and imported goods, whereas *ESUBM* is a parameter related to import substitution among trade

[1] `https://www.gtap.agecon.purdue.edu/models/default.asp`

Table 4.1: Armington substitution parameter

Region	*Sector*	*Substitution parameters (Armington parameters)*	
		Domestic and Imports (ESUBD)	*Among Source of Imports (ESUBM)*
USA China ASEAN EastAsia EU_27 RestofWorld	Agri	2.41	4.81
	Mining	5.69	13.01
	FoodProd	2.48	4.97
	TextApparel	3.78	7.59
	OthMfg	3.23	6.76
	PetroChem	2.84	5.9
	Metals	3.55	7.41
	MotorTrans	3.15	6.35
	ElecMach	4.27	8.59
	UtilConst	2.15	4.64
	OthServices	1.9	3.8

Source: Author

partners. Higher parameter values imply higher substitutability. *ESUBD* and *ESUBM* have different values depending on the sector, but are equally applied to all regions.

A modeler's decision on these parameters may be crucial to the outcome (Mcdaniel & Balistreri 2002). In this paper, the default Armington elasticities in the GTAP model are used. They are estimated by Hertel *et al.* (2007) based on a cross-sectional econometric analysis. These estimates are not only used in the GTAP model, but also have been widely used outside the GTAP community (Dixon *et al.* 2020). However, there is controversy about the correct estimates. Zhang (2006), Tsutsumi (2018), Cui *et al.* (2019), and Rosyadi & Widodo (2018) used the GTAP estimates in their CGE models to analyze the impact of trade wars. Devarajan *et al.* (2018) also assumed the same estimates for areas engaged in trade disputes, but low elasticities (0.5) were used in other regions. Li *et al.* (2018), on the other hand, simply set substitution elasticities of domestic and import goods to 2, with a sensitivity analysis range from 1.5 to 4.5. Song & Lee (2018) analyzed the main model using GTAP estimates, but also reported values assuming the elasticities were halved.

Following the precedents of these previous studies, GTAP estimates are used in this study, and the values are reported in Table 4.1. Considering that tariffs and trade volumes may be sensitive to Armington elasticities, sensitivity analysis was conducted. Higher elasticity makes it easier to substitute for different products, thus leading to smaller effects. Since this study focuses on the maximum damage that may occur in the decoupling situation, only the case of reducing elasticity is further estimated. Also, as mentioned in Chapter 3, as China's exports increase and the economy develops, their products are more specialized towards producing inputs for other countries. This tendency may suggest lower elasticities of demand for China: as the country becomes more specialized, it becomes more difficult for other countries to move away from trading with China. The sensitivity analysis results assuming the halved GTAP estimates are reported in Table A.3 in the appendix.

4.1 Data and Scenarios

Table 4.2: Regional aggregation

Aggregation label	*Aggregation description*	*Regions in GTAP*
USA	United States of America	United States of America.
China	China	China.
ASEAN	Association of Southeast Asian	Brunei Darussalam; Cambodia; Indonesia; Lao People's Democratic Republ; Malaysia; Philippines; Singapore; Thailand; Viet Nam; Rest of Southeast Asia.
EastAsia	East Asia	Hong Kong; Japan; Korea; Mongolia; Taiwan; Rest of East Asia.
EU_27	European Union 27	Austria; Belgium; Bulgaria; Croatia; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Romania; Slovakia; Slovenia; Spain; Sweden.
RestofWorld	Rest of World	Australia; New Zealand; Rest of Oceania; Bangladesh; India; Nepal; Pakistan; Sri Lanka; Rest of South Asia; Canada; Mexico; Rest of North America; Argentina; Bolivia; Brazil; Chile; Colombia; Ecuador; Paraguay; Peru; Uruguay; Venezuela; Rest of South America; Costa Rica; Guatemala; Honduras; Nicaragua; Panama; El Salvador; Rest of Central America; Dominican Republic; Jamaica; Puerto Rico; Trinidad and Tobago; Caribbean; United Kingdom; Switzerland; Norway; Rest of EFTA; Albania; Belarus; Russian Federation; Ukraine; Rest of Eastern Europe; Rest of Europe; Kazakhstan; Kyrgyzstan; Tajikistan; Rest of Former Soviet Union; Armenia; Azerbaijan; Georgia; Bahrain; Iran Islamic Republic of; Israel; Jordan; Kuwait; Oman; Qatar; Saudi Arabia; Turkey; United Arab Emirates; Rest of Western Asia; Egypt; Morocco; Tunisia; Rest of North Africa; Benin; Burkina Faso; Cameroon; Cote d'Ivoire; Ghana; Guinea; Nigeria; Senegal; Togo; Rest of Western Africa; Central Africa; South Central Africa; Ethiopia; Kenya; Madagascar; Malawi; Mauritius; Mozambique; Rwanda; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; Namibia; South Africa; Rest of South African Customs ; Rest of the World.

Source: Author

The CGE analysis is based on the latest GTAP 10A version database with 2014 as a reference year. The age of SAM is not necessarily important because CGE models are structural models (Burfisher 2016). The GTAP database consists of 141 regions and sixty-five industrial sectors. The 141 regions were divided into six categories: the US, China, the Association of Southeast Asian (ASEAN), East Asia, the European Union (EU), and the rest of the world. Table 4.2 shows the regional aggregation of the data. Sixty-five industrial sectors were re-categorized into eleven sectors: agriculture, mining, food production, textiles and apparel, manufacturing, petroleum and chemical products, metals, motor and transport, electrical equipment and machinery, utilities and construction, and services. A list of all aggregated sectors is given in Table 4.3. Finally, eight factors in GTAP were aggregated into five factors: land, unskilled labor, skilled labor, capital, and natural resources. Labor and capital are considered as mobile, while land and natural resources are assumed to be sluggish. The factor aggregation and the mobility assumption can be found in Table 4.4.

Table 4.3: Sectoral aggregation

Aggregated label	*Sectors in GTAP*
Agri	Paddy rice; Wheat; Cereal grains nec; Vegetables, fruit, nuts; Oil seeds; Sugar cane, sugar beet; Plant-based fibers; Crops nec; Bovine cattle, sheep and goats; Animal products nec; Raw milk; Wool, silk-worm cocoons; Forestry; Fishing.
Mining	Coal; Oil; Gas; Minerals nec.
FoodProd	Bovine meat products; Meat products nec; Vegetable oils and fats; Dairy products; Processed rice; Sugar; Food products nec; Beverages and tobacco products.
TextApparel	Textiles; Wearing apparel; Leather products.
OthMfg	Wood products; Paper products, publishing; Mineral products nec; Manufactures nec.
PetroChem	Petroleum, coal products; Chemical products; Basic pharmaceutical products; Rubber and plastic products.
Metals	Ferrous metals; Metals nec; Metal products.
MotorTrans	Motor vehicles and parts; Transport equipment nec.
ElecMach	Computer, electronic and optic; Electrical equipment; Machinery and equipment nec.
UtilConst	Electricity; Gas manufacture, distribution; Water; Construction.
OthServices	Trade; Accommodation, Food and servic; Transport nec; Water transport; Air transport; Warehousing and support activi; Communication; Financial services nec; Insurance; Real estate activities; Business services nec; Recreational and other service; Public Administration and defe; Education; Human health and social work a; Dwellings.

Source: Author

The simulation considered three main scenarios: a tariff increase (Scenarios 1 and 2), a decrease in trade (Scenarios 3 and 4), and a trade efficiency reduction (Scenario 5). These scenarios focus on analyzing how the economies of both countries would be affected if the changes triggered by a trade war lead to future economic decoupling. Table 4.5 summarizes all decoupling scenarios.

Table 4.4: Factor aggregation

Aggregated label	*Factors in GTAP*	*Mobility*
Land	Land.	-1
UnSkLab	Clerks; Service/Shop workers.	mobile
SkLab	Technicians/AssocProfessional; Officials and Managers; Agricultural and Unskilled.	mobile
Capital	Capital.	mobile
NatRes	Natural Resources.	-0.001

Source: Author

Scenarios 1 and 2 (Tariff): Scenarios 1 and 2 examine the effect of an increase in tariffs on the economy. In the early stages of the trade war, the United States and China imposed a 25% tariff on most traded commodities. (A detailed list can be found in the table in the appendix.) As an extension of this, the first decoupling scenario assumes that both countries impose a 25% tariff on all traded commodities. Furthermore, Scenario 2 considers the more extreme situation of a 45% tariff, which is the figure former US President Donald Trump said he supported as a tariff on Chinese goods in 2016. These two tariff hike scenarios offer a clearer picture of escalated trade war effects and decoupling situations.

Scenarios 3 and 4 (Trade): The first order impact from decoupling is the associated fall in exports (Cerdeiro *et al.* 2021). Therefore, Scenarios 3 and 4 consider a situation where the trade volume between the two countries decreases. Scenario 3 assumes an economic situation where imports between the US and China decline by 25% as a result of a trade war. Scenario 4 further examines a decoupling situation where the bilateral trade volume is cut in half. Cui *et al.* (2019) swapped the *tms* variable (import tariffs) and the *qxs* variable (export sales) in their GTAP CGE model in order to employ the trade volume as a shock. Following their research method, in Scenarios 3 and 4, import tariffs were assumed to be endogenous and export volumes to be exogenous.

Scenario 5 (Trade efficiency): In the process of decoupling, changes in indicators such as tariffs and trade volumes as well as changes in trade efficiency are seen. In GTAP, *AMS* variable captures trade efficiency changes, which are technically labeled as import-augmented technological changes. This variable was first introduced to treat efficiency-enhancing measures such as customs automation and e-commerce, which reduce the effective price of imported goods and services (Itakura & Hertel 2001). It shows an efficiency effect representing the change in the price of imports from trading partners (Fugazza & Maur 2008). In the fifth decoupling scenario, a 10% negative *ams* shock is given to both countries, which means 10% less of the product becomes available to domestic consumers and the effective price of imported goods increases in both countries.

Table 4.5: Decoupling experiment scenarios

Category	*Decoupling scenario description*	*GTAP shocks*
Tariff	Scenario 1 : Mutual tariff level increase to 25%	*Mutual 25% tms shock*
	Scenario 2 : Mutual tariff level increase to 45%	*Mutual 45% tms shock*
Trade	Scenario 3 : Bilateral trade decrease by 25%	*Mutual -25% qxs shock*
	Scenario 4 : Bilateral trade decrease by 45%	*Mutual -45% qxs shock*
Trade efficiency	Scenario 5 : Trade efficiency decrease by 10%	*Mutual -10% ams shock*

Source: Author

Chapter 5

Empirical Results

5.1 Welfare, GDP, Import and Export Changes, and Terms of Trade

After applying the shocks, the model was solved for a new equilibrium. Key macro results of each region are reported in Table 5.1. It can be noted that, to varying degrees, the results of all macro variables are consistent across the five decoupling scenarios. First of all, the welfare effect was measured using the equivalent variation. Only the US and China showed large negative welfare effects among all six regions in all decoupling scenarios. In the case of a 25% tariff increase, the welfare level in the United States decreased by approximately $45 billion, compared to $83 billion in China. The simulation results show that China's decline in welfare is greater than that of the US in all cases where tariffs increase, trade volume decreases, or trade efficiency decreases.

The welfare decline was greatest in Scenario 2, when both countries were shocked by a 45% tariff hike. It is interesting to note that in Scenario 4 and Scenario 5, the welfare of China decreased by a similar amount, while the welfare decline of the United States was more than doubled in Scenario 5. Also, in Scenario 5, the difference of welfare effects between the United States and China is not that great compared to other scenarios. It can be seen that the US consumer welfare responded more sensitively to the decrease in trade efficiency than to the decrease in trade volume.

Although China's welfare loss is greater than that of the United States under all scenarios, this does not necessarily imply that China is disadvantaged in the trade war. Calculated equivalent variations do not necessarily reveal the full circumstances. While the welfare effects on China are larger, China could be less sensitive to such measures due to their non-democratic political nature. Using the recent tariff escalation between the US and its trade partners, Fetzer & Schwarz (2021) analyzed whether retaliatory tariffs are politically targeted. Unlike other trading partners, China had hardly any feasible retaliation response that would correlate with the Republican vote share. This weak political targeting could imply that China is less affected by welfare effects or real income effects when it makes the decision on tariff raises.

Table 5.1: Main macro results of all scenarios

	USA	*China*	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Scenario 1 : Mutual tariff level increase to 25%						
EV(million USD)	-45290.39	-82851.38	6758.4	11502.55	14402.51	36485.07
GDP(%)	-0.21	-0.39	0.03	0.03	0.04	0.04
Export(%)	-3.81	-2.8	0.14	-0.26	-0.35	-0.07
Import(%)	-6.04	-7.14	1	1.12	0.25	1.1
ToT(%)	-0.42	-1.94	0.46	0.5	0.16	0.42
Scenario 2 : Mutual tariff level increase to 45%						
EV(million USD)	-86035.1	-114185.31	9739.38	15208.91	19428.22	51489.02
GDP(%)	-0.4	-0.6	0.04	0.03	0.05	0.05
Export(%)	-4.13	-3.37	0.2	-0.31	-0.45	-0.1
Import(%)	-7.56	-8.9	1.4	1.49	0.35	1.51
ToT(%)	-0.78	-2.52	0.66	0.66	0.21	0.59
Scenario 3 : Bilateral trade decrease by 25%						
EV(million USD)	-7214.47	-29006.27	2496.31	3730.13	5018.58	12637.55
GDP(%)	-0.04	-0.12	0.01	0.01	0.01	0.01
Export(%)	-1.88	-1.08	0.04	-0.1	-0.13	-0.03
Import(%)	-2.37	-2.82	0.35	0.36	0.09	0.38
ToT(%)	-0.07	-0.73	0.17	0.16	0.06	0.14
Scenario 4 : Bilateral trade decrease by 45%						
EV(million USD)	-25624.04	-60910.4	5246.28	7827.28	10452.01	26782.16
GDP(%)	-0.12	-0.28	0.02	0.02	0.03	0.03
Export(%)	-3.36	-2.1	0.08	-0.19	-0.26	-0.06
Import(%)	-4.65	-5.49	0.73	0.76	0.18	0.79
ToT(%)	-0.25	-1.45	0.36	0.34	0.12	0.31
Scenario 5 : Trade efficiency decrease by 10%						
EV(million USD)	-55431.44	-60403.9	4495.02	7328.62	9114.15	24075.59
GDP(%)	-0.27	-0.34	0.02	0.02	0.02	0.02
Export(%)	-1.56	-1.58	0.1	-0.15	-0.21	-0.06
Import(%)	-3.47	-4.02	0.66	0.72	0.17	0.7
ToT(%)	-0.4	-1.15	0.3	0.31	0.1	0.28

Source: Author

In all scenarios, the real GDP of both the US and China decreased. Like the equivalent variation (EV), only the US and China were harmed by GDP loss among all other regions and China suffered more than the US. According to the analysis of Scenario 1, the GDP of the US and China was estimated to decrease by 0.21% and 0.39%, respectively. The two countries' GDP declines were greatest in Scenario 2, where tariffs were raised to 45%. Other regions showed some GDP growth, which was less than 0.05% considering all scenarios. This means that the US has greater influence in the bilateral trade disputes in each scenario. Furthermore, such decreases in consumer welfare and real GDP can lead to the conclusion that economic decoupling is negatively affecting consumers as well as the economy in the US and China.

The change in imports and exports was also largest in the US and China. In the first scenario, exports in the US and China decreased 3.81% and 2.8%, respectively. While ASEAN countries' exports increased 0.14%, the East Asia and EU regions showed slight falls. Changes in imported value were the biggest among all macro variables. Imports in the US dropped about 6% and in China 7% in the first scenario, which is natural considering the high import taxes. Across all scenarios, there was a slight increase in regions where economic decoupling occurs, other than the United States and China. These results partly reflect the effect of the global value chain and the redistribution of trade flows, as the exports to the US and China shifted to other countries. On the other hand, exports declined in most regions, including the United States and China. The exception is the ASEAN region, where exports increased slightly. This means that there is a certain trade diversion effect, as discussed in the Section 5.2

The decline in exports caused by the trade dispute has affected the terms of trade in the two countries. In Scenario 1, the US terms of trade deteriorated by 0.42% and China by 1.94%. In all scenarios, China's terms of trade declined more than that of the US. This may be due to the fact that China was exporting more to the US. Except for these two countries, all regions benefit to some degree in terms of trade.

5.2 Change in Factor Incomes, and Sectoral Effects

To see which factor was hurt the most, ratios of return to primary factor to consumer price index (CPI) were calculated in Table 5.2. In all cases, land in the US presents a strikingly high loss compared to other countries and factors. On the other hand, natural resources in both countries and land in China had positive return ratios after the policy change.

Table 5.2: Real returns to factors of production (percentage change)

	USA	*China*	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Scenario 1 : Mutual tariff level increase to 25%						
Land	-7.56	5.84	-0.31	-1.31	0.09	-0.34
UnSkLab	-0.41	-1.09	0.3	0.19	0.09	0.21
SkLab	-0.4	-1.06	0.37	0.18	0.08	0.23
Capital	-0.41	-1.07	0.31	0.17	0.1	0.19
NatRes	1.28	8.86	-1.53	-1.65	-0.72	-1.66
Scenario 2 : Mutual tariff level increase to 45%						
Land	-10.04	7.82	-0.35	-1.66	0.31	-0.28
UnSkLab	-0.62	-1.48	0.41	0.25	0.11	0.29
SkLab	-0.57	-1.43	0.53	0.23	0.1	0.31
Capital	-0.6	-1.44	0.43	0.22	0.13	0.25
NatRes	2.35	11.81	-2.07	-1.94	-0.72	-2.07
Scenario 3 : Bilateral trade decrease by 25%						
Land	-4.07	2.23	-0.04	-0.4	0.1	-0.05
UnSkLab	-0.14	-0.43	0.11	0.06	0.03	0.08
SkLab	-0.14	-0.41	0.14	0.06	0.03	0.08
Capital	-0.15	-0.41	0.11	0.05	0.03	0.07
NatRes	0.12	3.3	-0.57	-0.52	-0.28	-0.63
Scenario 4 : Bilateral trade decrease by 45%						
Land	-7.66	4.58	-0.08	-0.83	0.23	-0.07
UnSkLab	-0.3	-0.86	0.22	0.13	0.06	0.16
SkLab	-0.3	-0.84	0.29	0.12	0.05	0.17
Capital	-0.31	-0.84	0.22	0.11	0.07	0.14
NatRes	0.71	6.72	-1.16	-1.04	-0.49	-1.23
Scenario 5 : Trade efficiency decrease by 10%						
Land	-2.95	3.38	-0.24	-0.83	0.08	-0.19
UnSkLab	-0.33	-0.68	0.18	0.12	0.05	0.13
SkLab	-0.3	-0.65	0.25	0.12	0.05	0.14
Capital	-0.31	-0.66	0.2	0.11	0.06	0.12
NatRes	1.68	5.45	-0.92	-0.93	-0.27	-0.87

Source: Author

Real wages in the US and China also declined across all scenarios. Compared to before the shock, the extent of the decline in wages was slightly larger in China. There was little difference between skilled labor and unskilled labor, but the negative impact on wages of unskilled labor was slightly greater. In addition, when wages in the US and China decreased, wages in other regions rose, with the largest increase in the ASEAN region. Return on capital also showed similar patterns to wage. It decreased in both the US and China, but the decline was larger in China. Among other regions, the increase in return on capital was the largest in ASEAN, followed by East Asia.

Table 5.3: Impact on sectoral output in the USA and China (percentage change)

	S1		*S2*		*S3*		*S4*		*S5*	
	USA	*China*	*USA*	*China*	**USA**	*China*	**USA**	*China*	*USA*	*China*
Agri	-1.32	1.16	-1.77	1.54	-0.71	0.45	-1.36	0.92	-0.48	0.69
Mining	0.26	1.48	0.54	1.95	0.05	0.57	0.17	1.13	0.28	0.94
FoodProd	0.38	0.26	0.46	0.3	0.12	0.09	0.25	0.17	0.2	0.16
TextApparel	4.64	0.93	8.9	-0.66	2.67	-0.52	5.51	-1	4.71	-0.24
OthMfg	1.01	-1.02	1.54	-1.26	0.33	-0.39	0.74	-0.77	0.77	-0.45
PetroChem	0.41	0.72	0.72	0.96	0.07	0.24	0.22	0.48	0.44	0.5
Metals	1.11	0.36	1.92	0.76	0.19	0.23	0.61	0.47	1.07	0.33
MotorTrans	-1.52	1.21	-2.29	2.05	-0.92	0.62	-1.7	1.26	-1.07	1.08
ElecMach	2.64	-1.02	3.92	-0.76	0.72	-0.13	1.66	-0.25	2	-0.36
UtilConst	-1.23	-1.29	-1.65	-1.72	-0.39	-0.49	-0.82	-0.99	-0.86	-0.8
OthServices	-0.06	-0.02	-0.14	-0.05	0	-0.01	-0.03	-0.02	-0.09	-0.05

Source: Author

Unlike other factors that decreased in both countries, land and natural resources showed a different pattern. One of the possible reasons could be the factor mobility assumption. Land and natural resources were set as sluggish factors in the model assumption, and this immobility may have influenced the results. Secondly, the US exports a high volume of agricultural products to China, and as mentioned in Chapter 3, the terms of the Phase One agreement require purchases in this sector. The third possible interpretation can be made using the Stolper-Samuelson theorem, which describes the effects of price shocks with relative intensity of factors or production. In all scenarios, China's capital and labor income fell, but land rental income rose. The decline in agricultural imports from the United States may have boosted Chinese demand for agricultural products. The decline in China's manufacturing exports may also have had an impact, as manufacturing is a labor-intensive industry. Increased demand for land may have pushed land rental incomes up and the surplus of labor pushed wages down.

Table 5.3 shows the output changes by sector in the US and China. In all decoupling scenarios, the US showed a decline in agricultural and motor vehicles output. On the other hand, in China, production in the electrical equipment and manufacturing sectors decreased. This result indicates that the production of the main export products of the two countries has decreased due to the effect of economic decoupling. In the case of the US, the figures are relatively high in the textiles and manufacturing sectors, which may be an effect of increasing domestic sales due to the substitution of imported intermediary inputs.

Table 5.4: S1: Export changes

	Exports from the USA				
	China	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-54.25	7.04	5.37	8.04	7.79
Mining	-90.52	1.99	2.29	2.4	2.26
FoodProd	-47.94	4.57	3.5	4.8	5.11
TextApparel	-68.65	-3.44	-4.57	-0.14	-1.88
OthMfg	-71.58	2.18	2.08	4.03	3.42
PetroChem	-61.97	1.85	1.4	2.44	2.1
Metals	-76.53	0.79	1.26	3.12	2.99
MotorTrans	-48.91	1.69	1.71	2.34	2.08
ElecMach	-81.29	-2.31	-3.46	-0.58	-1.49
UtilConst	-64.21	3.97	3.88	3.62	4.17
OthServices	-55.92	3.69	3.32	3.32	3.8
	Exports from China				
	USA	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-62.81	5.62	3.91	6.84	6.39
Mining	-89.87	8.33	8.23	8.4	8.3
FoodProd	-58.39	9.8	8.62	10.1	10.3
TextApparel	-41.88	9.74	8.57	13.62	11.55
OthMfg	-67.37	11.32	11.19	13.4	12.53
PetroChem	-63.84	8.59	8.17	9.26	8.85
Metals	-72.08	11.19	11.79	13.82	13.56
MotorTrans	-69.73	12.3	12.22	13	12.72
ElecMach	-76.07	12.19	10.89	14.14	13.08
UtilConst	-60.76	11.73	11.63	11.35	11.95
OthServices	-52.58	11	10.6	10.6	11.11

Source: Author

In order to analyze the trade diversion effect, Table 5.4, Table 5.5, Table 5.6, Table 5.7, andTable 5.8 report changes in export by country and industry for each scenario. The top tables represent the change in US exports, and the bottom tables indicate the change in China.

Table 5.5: S2: Export changes

	Exports from the USA				
	China	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-75.74	10.68	7.86	11.71	11.4
Mining	-102.02	0.46	1.01	1.25	1.29
FoodProd	-74.15	7.06	5.37	7.19	7.66
TextApparel	-88.14	-2.55	-5.47	0.3	-2.04
OthMfg	-87.92	4.03	3.69	6.39	5.55
PetroChem	-83.67	2.92	2.2	3.58	3.13
Metals	-88.94	2.21	2.73	5.27	5
MotorTrans	-78.6	3.27	3.14	4.12	3.65
ElecMach	-88.49	-1.64	-3.06	0.84	-0.5
UtilConst	-81.36	6.15	5.83	5.55	6.34
OthServices	-74.33	5.61	4.99	5.03	5.71
	Exports from China				
	USA	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-81.2	7.67	4.85	9.04	8.48
Mining	-219.32	10.96	10.97	11.17	11.05
FoodProd	-79.65	13.15	11.28	13.37	13.68
TextApparel	-76.71	14.63	11.33	18.33	15.57
OthMfg	-86.54	15.18	14.8	17.92	16.7
PetroChem	-84.02	11.57	10.85	12.33	11.78
Metals	-90.08	14.73	15.64	18.49	18.02
MotorTrans	-87.49	16.21	16.08	17.18	16.66
ElecMach	-92.37	16	14.33	18.94	17.32
UtilConst	-79.35	15.84	15.5	15.18	16.05
OthServices	-72.27	14.79	14.12	14.16	14.9

Source: Author

In the first and second scenarios, overall transactions between China and the United States declined due to reciprocal import taxes. In the United States, when tariffs rose, exports in all sectors fell considerably. Among them, exports of natural resources such as coal, oil and gas suffered the most (*Mining*). Since the US tariffs were only imposed on China, overall exports to other regions increased while exports to China decreased. However, the textiles, apparel and leather sectors (*TextApparel*) and machinery and electronics sectors (*ElecMach*) show declines in exports across all regions for Scenario 1. Similarly, in the second scenario, exports of these two sectors deteriorated overall, but showed a slight increase in the EU region. China's exports to the US also declined appreciably in Scenarios 1 and 2. However, exports to other regions rose considerably more than US exports to other regions. China's exports to the US recorded the largest declines in natural resources (*Mining*), followed by machinery (*ElecMach*) and metal products (*Metals*).

Table 5.6: S3: Export changes

	Exports from the USA				
	China	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-25	3.03	2.24	3.28	3.19
Mining	-25	0.6	0.73	0.76	0.71
FoodProd	-25	1.51	1.06	1.54	1.67
TextApparel	-25	-1.67	-2.62	-0.92	-1.53
OthMfg	-25	0.31	0.23	0.99	0.79
PetroChem	-25	0.41	0.23	0.64	0.53
Metals	-25	-0.29	-0.07	0.66	0.62
MotorTrans	-25	0.26	0.28	0.51	0.43
ElecMach	-25	-1.47	-1.87	-0.67	-0.99
UtilConst	-25	1.09	1	0.97	1.17
OthServices	-25	1.04	0.87	0.91	1.09
	Exports from China				
	USA	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-25	2.18	1.37	2.49	2.33
Mining	-25	3.07	3.05	3.1	3.05
FoodProd	-25	3.57	3.09	3.63	3.71
TextApparel	-25	4.16	3.19	5	4.33
OthMfg	-25	4.15	4.06	4.88	4.61
PetroChem	-25	3.17	3	3.42	3.29
Metals	-25	4	4.26	5.01	4.93
MotorTrans	-25	4.43	4.41	4.69	4.6
ElecMach	-25	4.36	3.95	5.19	4.86
UtilConst	-25	4.27	4.17	4.15	4.35
OthServices	-25	4.01	3.84	3.88	4.06

Source: Author

In Scenarios 3 and 4, the change in bilateral trade volumes between the US and China is constant. This is because the decrease in bilateral trade volume was given as a shock in these scenarios. As in the previous scenarios, US exports in machinery and apparel declined in all regions. Although small, there was a decrease in metal exports to ASEAN and East Asia in Scenario 1. In the remaining sectors, trade diversions to other regions occurred as exports to China declined. In particular, the agricultural sector of the United States demonstrated a relatively large increase in exports to other regions. China's exports also showed a similar pattern to the previous scenarios. Exports to all regions except the United States increased. Among them, exports of motor vehicles and parts (*MotorTrans*), machinery (*ElecMach*), and metal products (*Metals*) showed a relatively high rate of change.

Table 5.7: S4: Export changes

	Exports from the USA				
	China	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-50	6.41	4.7	6.89	6.71
Mining	-50	1.21	1.48	1.54	1.44
FoodProd	-50	3.48	2.51	3.52	3.77
TextApparel	-50	-2.53	-4.5	-1.17	-2.38
OthMfg	-50	1.26	1.06	2.6	2.18
PetroChem	-50	1.17	0.77	1.59	1.35
Metals	-50	0.05	0.49	1.95	1.83
MotorTrans	-50	1.01	1.03	1.52	1.31
ElecMach	-50	-2.22	-3	-0.64	-1.33
UtilConst	-50	2.68	2.48	2.4	2.82
OthServices	-50	2.49	2.13	2.21	2.57
	Exports from China				
	USA	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-50	4.34	2.63	4.93	4.62
Mining	-50	6.14	6.12	6.22	6.12
FoodProd	-50	7.21	6.18	7.3	7.48
TextApparel	-50	8.52	6.42	10.15	8.74
OthMfg	-50	8.41	8.19	9.91	9.31
PetroChem	-50	6.41	6.02	6.88	6.59
Metals	-50	8.09	8.63	10.18	9.97
MotorTrans	-50	8.95	8.9	9.48	9.25
ElecMach	-50	8.8	7.95	10.52	9.76
UtilConst	-50	8.7	8.49	8.41	8.85
OthServices	-50	8.16	7.78	7.86	8.25

Source: Author

Scenario 5 also showed results not essentially different from the previous scenarios. As trade efficiency decreased, the US and China directly affected each other, and most regions benefited from increased exports. Though there are some differences, all five scenarios showed similar results. When economic decoupling proceeded, trade between China and the United States decreased, and was replaced by trade with third countries to some extent. Although direct trade between the United States and China decreased, it should also be considered that export through a third country is possible.

Table 5.8: S5: Export changes

	Exports from the USA				
	China	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-27.02	4.35	3.23	4.78	4.67
Mining	-71.21	1.58	1.77	1.8	1.7
FoodProd	-31.84	3.55	2.84	3.64	3.82
TextApparel	-50.41	-0.44	-1.89	0.77	-0.25
OthMfg	-43.13	2.7	2.57	3.71	3.3
PetroChem	-38.77	1.9	1.57	2.13	1.9
Metals	-48.1	1.87	2.17	3.23	3.06
MotorTrans	-39.42	2.08	2.09	2.44	2.17
ElecMach	-54.66	0.12	-0.52	1.18	0.52
UtilConst	-31.16	3.41	3.32	3.12	3.46
OthServices	-23.94	3.05	2.81	2.79	3.08
	Exports from China				
	USA	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-30.95	3.62	2.46	4.18	3.94
Mining	-70.19	4.78	4.77	4.82	4.73
FoodProd	-30.39	5.84	5.07	5.95	6.05
TextApparel	-34.12	6.7	5.21	8.07	6.92
OthMfg	-36.04	6.68	6.52	7.75	7.2
PetroChem	-35.64	5.1	4.78	5.34	5.08
Metals	-42.26	6.54	6.89	7.99	7.74
MotorTrans	-39.17	6.9	6.86	7.28	6.99
ElecMach	-42.21	7.01	6.34	8.12	7.4
UtilConst	-28.12	6.91	6.82	6.61	6.96
OthServices	-21.32	6.44	6.2	6.17	6.47

Source: Author

5.3 Sensitivity Test

As discussed in the previous section, the size of the Armington elasticities has a substantial impact on the outcome of the analysis. Therefore, in order to incorporate the sensitivity of the analysis result, another analysis was conducted assuming that the elasticity estimates in Table 4.1 were halved. For simplicity, the alternative elasticity was applied only to the first scenario out of five. New elasticity and its main model results are reported in Table A.3 and Table A.4 of the Appendix A, respectively.

As a result of the analysis, the predicted decoupling effects were nearly the same even though the model sensitivity was assumed to be halved. Consumer welfare, GDP, import volume and terms of trade in the US and China diminished. Land rental income in the US decreased and in China increased, and capital and wage income declined in both countries. However, there was a difference in export volume changes in China, the US and ASEAN. When elasticity was reduced by half, exports from the US and China increased as exports from ASEAN countries decreased. This can be interpreted as a result of the decrease in elasticity, which made it difficult to switch trade to different regions.

5.4 Limitations of the Study

The limitations of this study are as follows. The first are the dynamics of the model. When a tariff increase is introduced as a shock, it is possible to see the change immediately in static models. However, the static model cannot analyze the change that occurs when the tariff persists, which might change economic behaviour such as investing. If the investment diverts and it has a cumulative effect, the distribution of capital across countries will be different in the long run. The comparative static CGE model is limited in that it does not capture the potential long-term effects of the trade war.

The second limitation is the model closure. In this study, the labor market was cleared without unemployment, according to the neoclassical closure rule. As much as President Trump mentioned job losses in manufacturing, unemployment is also an important factor in understanding the trade war. However, this study has limitations in that the unemployment effect was not taken into account.

The third limitation is the set of model assumptions. The Standard CGE model uses several strong assumptions, including a perfectly competitive market with a uniform production function across all regions and industries. This assumption does not allow for diverse producers with different types of technologies in different economic situations. Moreover, the financial market and monetary sector are absent in the model. Lastly, the model used in this study is deterministic and does not account for any randomness.

The fourth limitation are the parameters. Analysis results can vary greatly depending on the values of behavioral parameters. Furthermore, there is a shortcoming in that the Armington parameters ($ESUBD$, $ESUBM$) are region-generic. They do not allow the degree of elasticity to vary by region, though in reality some countries might be more flexible to certain industries.

Finally, the model scenario could be more sophisticated. In this study, to account for the maximum effect of decoupling, shocks such as an increase in tariffs, a decrease in export volume, and a decrease in trade efficiency were applied to all sectors in both economies. However, realistically, if decoupling proceeded, there is a high probability that it would occur to different extents within each specific industry rather than to the same extent in all fields.

Chapter 6

Conclusion

In this paper, the impact of the US-China trade conflict on the economy is analyzed from the point of view of economic decoupling.

First, the study addressed through trade statistics whether the large trade deficit with China, which was one of the US economic rationales behind the US-China trade war, was truly the core catalyst for the trade war. It was pointed out that the US has a trade deficit in merchandise but a trade surplus in service with China. It was also pointed out that the global value chain should be considered when trade balance is interpreted. As China took over Japan's role of Asian factory hub, China became specialized in manufacturing. In 1995, the United States imported goods directly from Japan, but now goods produced in Japan are shipped to China, assembled and exported to the United States. This shift in supply chain must be considered. It also examined how excess saving in China and inadequate saving in the US contributed to trade imbalance, because the US has to import surplus savings from abroad by running current account deficits, while, China has a huge overall current account surplus.

As part of this analysis, the cause of the US-China trade war was not described simply as a trade imbalance, but as a political maneuver in the battle for international dominance. It was also conjectured that the problem is likely to continue into the future as long as the United States's increasing frustration and China's ambitions for growth collide. Therefore, this study analyzed five decoupling scenarios in the US and China using the CGE GTAP model. The findings and discussion are as follows.

The five scenarios used in the analysis are: tariff increase (Scenarios 1 and 2), quantitative intervention applied (Scenarios 3 and 4), and trade efficiency decrease (Scenario 5). As a result of the analysis, the welfare and the GDP of the US and China decreased in all scenarios, and the decrease in China was larger than that of the US. It was also confirmed that when the welfare of both countries decreased, the rest of the world experienced a welfare gain. When exports from the US and China decreased, exports from the ASEAN region increased, presumably due to the GVC effect. The output of the US agricultural and automotive industries and China's manufacturing and electronic machinery industries were hit hard in all scenarios. Also, the large decrease in real returns to land in the US was interpreted using the Stolper-Samuelson theorem.

Finally, when the sensitivity analysis was performed with the elasticity reduced by half, all macro indicators showed the same behavior as the main analysis. However, the export volume changes demonstrated the opposite result from the main analysis. Exports from China and the United States increased and exports from the ASEAN region decreased. This is interpreted as a result of the decrease in elasticity and the difficulty in transitioning to other regions.

When comparing the results with other literature studies using the GTAP CGE model shown in Table 2.1 of Chapter 2, this study used relatively recent data and used a slightly different model specification. The results were similar to other related studies in showing that China's losses would be greater than those of the US, that China's manufacturing industry would suffer, and that the trade diversion effect would be felt in Asia. This paper contributes to the larger discussion by using more current and detailed GTAP data compared to other papers. In addition, it is different from other papers in that a potential decoupling is analyzed by assuming three different situations: tariff increase, trade volume decrease, and trade efficiency decrease.

Limitations of this paper include using a comparative static model rather than a recursive dynamic model and excluding unemployment from the analysis. Another disadvantage of this study is that strong assumptions are used in the standard CGE model and that the Armington parameters are region-generic. Finally, it is a limitation that the shock of the five scenarios used in the model analysis was applied equally to all sectors.

In conclusion, the CGE model analysis suggests that the United States has more leverage, but both the United States and China would suffer losses. However, as addressed in Chapter 5, because of its political system, China may be less sensitive to smaller reductions of welfare. Also, as revealed in Chapter 3, it is worth noting that circumstances may differ in the future as China is reducing its dependence on trade with the United States and reducing tariffs for other countries, further enhancing the competitiveness of its manufacturing industry. Even if China reduces its trade dependence on the United States, trade with other countries is essential for China's industrial program, including Made in China 2025. If the US is justified in pointing out China's unfair trade practices such as intellectual property theft and government interference in high-tech industries, eventually, a global trade order will have to be established that addresses issues such as intellectual property protection, and government subsidies restrictions.

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Appendix A

Additional Tables

Table A.1: Income parameter

	USA	*China*	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	0.23	0.36	0.48	0.29	0.22	0.48
Mining	0.98	1.1	1	1.02	1.04	1.07
FoodProd	0.46	0.36	0.46	0.43	0.46	0.51
TextApparel	0.54	0.47	0.54	0.55	0.54	0.58
OthMfg	0.98	1.04	1	1.01	1.04	1.03
PetroChem	0.93	0.98	0.96	0.94	0.98	0.99
Metals	0.98	1.04	1.03	1.03	1.04	1.06
MotorTrans	0.98	1.04	1	1.01	1.04	1.04
ElecMach	0.96	0.98	0.99	1.01	1.03	1.03
UtilConst	0.98	1.1	1.06	1.01	1.04	1.07
OthServices	1.07	1.39	1.3	1.1	1.13	1.19

Source: Author

Table A.2: Substitution parameter

	USA	*China*	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	0.7	0.75	0.8	0.71	0.78	0.83
Mining	0.12	0.5	0.64	0.26	0.22	0.48
FoodProd	0.23	0.75	0.78	0.45	0.38	0.64
TextApparel	0.2	0.69	0.71	0.38	0.32	0.59
OthMfg	0.12	0.52	0.53	0.24	0.2	0.4
PetroChem	0.12	0.53	0.6	0.26	0.22	0.46
Metals	0.12	0.52	0.55	0.23	0.2	0.42
MotorTrans	0.12	0.52	0.53	0.25	0.2	0.35
ElecMach	0.12	0.53	0.5	0.24	0.2	0.38
UtilConst	0.12	0.5	0.53	0.24	0.22	0.42
OthServices	0.12	0.46	0.5	0.23	0.19	0.34

Source: Author

Table A.3: Sensitivity test : Armington parameter

Region	*Sector*	*Substitution parameters (Armington parameters)*	
		Domestic and Imports (ESUBD)	*Among Source of Imports (ESUBM)*
USA China ASEAN EastAsia EU_27 RestofWorld	Agri	1.21	2.4
	Mining	2.85	6.51
	FoodProd	1.24	2.48
	TextApparel	1.89	3.79
	OthMfg	1.61	3.38
	PetroChem	1.42	2.95
	Metals	1.77	3.71
	MotorTrans	1.58	3.17
	ElecMach	2.13	4.29
	UtilConst	1.08	2.32
	OthServices	0.95	1.9

Source: ADD SOURCE

Table A.4: Sensitivity test: Macro results

	USA	*China*	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Macro results						
EV(million USD)	-73052.89	-102873.7	11018.37	21618.84	29666.88	76187.95
GDP(%)	-0.16	-0.31	0.03	0.04	0.06	0.05
Export(%)	1.27	0.38	-0.59	-1.33	-0.85	-1.07
Import(%)	-5.86	-5.74	0.8	1.09	0.29	1.3
ToT(%)	-1.84	-3.25	0.76	0.96	0.35	0.95
Ratio of return to primary factor to consumer price index(percent change)						
Land	-2.13	4.07	-0.29	-1.22	0.05	-0.48
UnSkLab	-0.78	-1.48	0.54	f 0.37	0.19	0.46
SkLab	-0.82	-1.44	0.54	0.33	0.17	0.46
Capital	-0.78	-1.44	0.47	0.32	0.2	0.39
NatRes	7.08	10.66	-1.62	-2	-0.92	-2.75

Source: Author

Table A.5: Sensitivity test: Export changes

	Exports from the USA				
	China	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-31.66	5.64	4.69	6.95	6.84
Mining	-75.55	4.2	4.37	4.33	4.25
FoodProd	-26.4	6.19	5.41	6.79	7.05
TextApparel	-41.72	0.98	1.39	5.4	3.72
OthMfg	-44.74	6.16	6.22	8.21	7.55
PetroChem	-36.93	3.84	3.39	4.51	4.13
Metals	-49.65	5.34	5.52	7.48	7.1
MotorTrans	-27.22	5.5	5.42	6.04	5.69
ElecMach	-54.94	3.46	2.65	5.62	4.53
UtilConst	-39.4	6.92	7.43	6.68	7.45
OthServices	-32.08	5.68	5.48	5.49	6
	Exports from China				
	USA	*ASEAN*	*EastAsia*	*EU_27*	*RestofWorld*
Agri	-36.51	6.97	5.89	8.71	8.31
Mining	-73.44	11.41	11.08	11.12	11.05
FoodProd	-33.88	9.02	8.15	9.68	9.79
TextApparel	-22.2	7.18	7.71	11.99	10.07
OthMfg	-41.16	9.53	9.54	11.64	10.77
PetroChem	-38.35	7.33	6.89	8.01	7.58
Metals	-45.13	9.32	9.59	11.59	11.04
MotorTrans	-44.25	10.42	10.25	10.98	10.58
ElecMach	-48.62	9.67	8.84	11.95	10.74
UtilConst	-36.77	10.11	10.63	9.86	10.65
OthServices	-29.97	8.89	8.68	8.69	9.22

Source: Author