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Angela Li
University of Toronto Schools, lian@utschools.ca

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A CGE-Model Analysis of U.S. Imposed Automotive Tariffs

Abstract

Using a computable generable equilibrium (CGE) model, this research paper evaluates the effects of a U.S. imposed 25% automotive import tariff on NAFTA countries and the European Union, the greatest U.S. automotive trade partners. Three simulations were conducted: the implementation of tariffs with no retaliation, equivalent retaliation on the same products, and retaliation on the top exports of politically significant states, with sensitivity analysis applied in the final scenario. The results demonstrate that the EU is marginally affected while the NAFTA countries experience the greatest increases in prices and reduction in total wages.

Keywords

Tariffs, CGE Model, Macroeconomics, Automotive Trade, NAFTA

Cover Page Footnote

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1. Introduction

On May 23, 2018, the U.S. Department of Commerce announced an investigation under Section 232 of the Trade Expansion Act of 1962 on whether imports of automobiles, sport utility vehicles, vans and light trucks, and automotive parts pose a threat to the "national security" of the United States. Within 270 days after the investigation, Commerce will submit a report to President Trump with a decision on the subject and recommendations for action, likely to be tariffs if the goods are affirmed to be a threat to national security. In light of Trump's belligerent rhetoric and proposals for 25% import tariffs on automotive parts and finished vehicles, the likelihood of following the direction of the steel and aluminum tariffs imposed in March are high. Nearly 98% of the targeted automotive imports by value would affect the European Union, Canada, Japan, Mexico, and South Korea, all of which are key allies to the U.S. Although Trump's meeting with European Commission President Jean-Claude Juncker in July resulted in negotiations for eliminating tariffs between the two countries, no specific commitments were made on the threatened automotive tariffs, indicating that the potential for tariffs on European Union automotive imports still exists. The consensus among U.S. lawmakers and the auto industry is that automotive tariffs would only hike prices for consumers and harm overall employment.

This research paper analyzes the net economic impacts of a 25% import tariff on automotive parts and finished vehicles from all countries without exemptions under three scenarios: implementation of tariffs with no retaliation, tariffs with retaliation at the same rate back on the same automotive products from Canada, Mexico, the EU and Japan, and tariffs with retaliatory measures imposed by the same aforementioned countries on the top exports of politically significant states in the U.S (coal, oil and petroleum and coal products). The focus on

the paper is on the impacts on impacts to workers, consumers and overall welfare in the 3 NAFTA countries and the EU. These regions were chosen specifically as Canada, Mexico and the EU form the greatest share of the value of U.S. automotive exports and imports, as stated by the Peterson Institute for International Economics (2018).

Compared to other studies on the subject, the paper focuses on broader scenarios, with emphasis on analyzing how the different forms of retaliation affect the countries in question. The computable general equilibrium model used in this paper accounts for the tariff being imposed with no exemptions, with shocks applied to all countries. Furthermore, sensitivity analysis is applied, where elasticity is doubled to gauge the effects of more substitutable automotive products.

The paper is structured as follows: Section 2 reviews related literature and Section 3 explains how the GTAP CGE model is used as a quantitative framework. Section 4 describes the current trade context for the U.S., Canada, Mexico, the EU and Japan, Section 5 examines the results and Section 6 summarizes the conclusions of the paper's findings.

2. Literature Review

Given the recent nature of the proposed tariffs, there have not been extensive studies released which have analyzed its impacts. Of the studies available, there has been a focus on short term impacts over a 1-3 year period, with the assumption that producers have limited ability to significantly increase domestic production to replace imports and to diverge sourcing away from the complex cross-border supply chains. Among these studies however, there is general consensus that the United States' proposed tariffs of 25% on imports from the automotive sector would pose significant harms overall to American workers. Francois, Baughman and Anthony (2018) conducted a study using a structurally estimated general equilibrium (SEGE) model of production and trade which integrates the GTAP database. They concluded that, assuming no retaliation, the imposed tariffs would cause an increase of 92,000 high-skilled jobs the auto sector which would be offset by the loss of 250,000 other high-skilled and low-skilled jobs in other sectors of the economy. The study conducted by Francois et. al noted how the varying impacts resulting from this policy were interconnected. They predicted that the highest loss of jobs would be in the service sector jobs, such as those related to trade and distribution, construction and high-skilled business and professional services, as these are the jobs most dependent on production in the manufacturing sectors. The manufacturing sector would be harmed by the tariffs, which raise the price for motor vehicles and parts--for instance, tariffs would add approximately $6400 to the price of an imported higher costs for motor vehicles and parts. In the study, overall impacts on the economy were also assessed. Tariffs are estimated to cause a net decline in the output of the U.S. economy of 0.1 percent in the time period of 1-3

years, due to higher prices which makes U.S. exports less competitive, and new car purchases more expensive.

Another study conducted by Robinson et.al (2018) of the Peterson Institute for International Economics used a global computable general equilibrium (CGE) simulation model, called GLOBE. They analyzed both the scenario where there is no retaliation and one with retaliation on the same products. They concluded that in the former case approximately 195,000 U.S. jobs overall would be lost, whereas in the latter 624,000 US jobs would be lost, and 5 percent of the workforce in the auto and parts sectors would be displaced. Their findings emphasize how reliant the domestic sectors in the U.S. are on intermediate inputs that are not produced in the United States currently or that do not have a readily accessible U.S. produced substitute. Consistent with most other studies, prices are expected to rise for both imported and domestically produced vehicles. According to Robinson et.al, some automakers may shift production locations to the United States to avoid tariffs; however, it is a complex decision which may not necessarily always result in relocation to the U.S. as there are the considerations of the cost of broken supply chains, investment uncertainties from Trump's volatile trade policies and reduced demand due to higher prices.

This is corroborated by the Centre for Automotive Research study which used a simulation model of the U.S light vehicle industry assuming unitary demand elasticity and that the full costs of the imposed tariff or quota are fully passed through to consumer prices. The study demonstrated how the declining demand for automotive vehicles (of up to 2 million vehicles) would be associated with employment losses from over 82, 000 to nearly 750, 000 jobs, a $6.4

billion decline in the U.S. Gross Domestic Product. The Centre's study focused on how new vehicle dealerships would be substantially harmed, having impacts for the wider U.S. economy as well, given that these businesses collectively employ more than 1.1 million people. The United States' 17,000 new vehicle dealerships provide significant contributions to the U.S. economy. Employment in these new vehicle dealerships would decline by 28,800 workers, to 117,500 workers.

Due to the interconnected nature and magnitude of trade between the three NAFTA countries, the tariff will be particularly harmful for Canada and Mexico. The effects on Canada have also been studied by DePratto (2018), who demonstrated how given the concentration of the auto sector, the province of Ontario in Canada would be the most impacted by the tariffs, with growth reduced by up to two percentage points. The impact would reach far beyond just the auto sector, as other manufacturers supply auto companies with intermediate inputs such as packaging material, glassmakers and die casting. The entire manufacturing sector of Canada would be affected, with a potential loss of 1 in 5 manufacturing jobs nationwide. Mexico would experience potentially even graver losses, as many automotive corporations have assembly plants specifically to serve the U.S. market. According to Linnane (2018) Mexico exported 82% of its produced vehicles in 2017, of which 84% was to the U.S. and Canada.

3. Model Design

In this paper, the effects of Trump's proposed tariffs on automobile parts and finished vehicles are studied with the Computable General Equilibrium (CGE) model GTAP. This model, based on the GTAP database, is a tool used worldwide for empirical economic analysis. For example, most recently, it was used by the U.S. Commerce Department and Canadian Finance Ministry to analyze the impact of the steel and aluminum tariffs. The following paragraphs discuss how the computable general equilibrium model framework with the GTAP 7 data set is applied to study multiple scenarios of reactive measures to the tariffs imposed by the U.S. on imports from the auto sector.

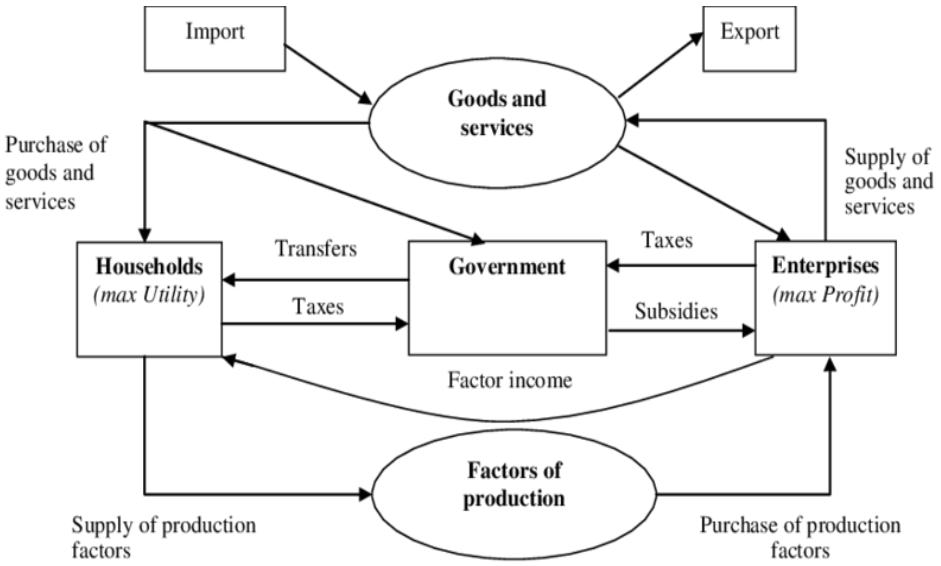
3.1 The Computable General Equilibrium (CGE) Model

The CGE model serves to proxy the global economic system by simplifying interactions between important economic agents such as consumers, producers and the government. It is based on numerous assumptions, such as cost-minimizing behaviour by producers, average-cost pricing, and household demands based on optimizing behaviour. Households and businesses that are defined in each model interact on a microeconomic level through transactions, feeding into

macroeconomic relationships such as employment, GDP growth and investment. According to Wing and Balistreri (2012), CGE models are often referred to as micro-macro models because of that structure.

The framework is illustrated below in Figure 1 in a circular flow diagram, which depicts the various interactions in a simplified economy. Consumers (represented by households below) purchase goods and services from domestic producers, as well as import finished goods from other countries, while producers (represented by enterprises below) pay consumers for the factors of production they provide through capital rent and wages. Furthermore, producers purchase intermediate inputs from each other, import intermediate goods and export goods and intermediate inputs to other countries. The government interacts in the economy as well by paying subsidies and transfers to consumers and taxing both consumers and producers. The analysis on U.S. imposed auto tariffs will focus on the transactions between the four economic agents: consumers, producers, the government, and foreign firms.

Figure 1: Circular Flow Diagram of Interactions in an Economy



3.2 The GTAP Framework

GTAP relies upon the assumption of perfect competition and constant returns to scale, as well as Armington's assumption, which differentiates commodities by their country of origin and models imports from different sources to be imperfect substitutes. With 140 countries and 57 categories of goods in the Version 7 database of 2011, the model is particularly beneficial for analyzing varying impacts to sectors, regions and factors of production (labour, capital, land, etc). According to Mensbrugghe (2015), the model tracks the flow of bilateral trade between any pair of regions for all sectors and also measures international capital flows which respond to relative changes in expected rates of capital returns across regions.

3.3 Aggregations and Variables

The geographic aggregation comprises of the NAFTA countries and their main trading partners of automotive parts and finished vehicles. The NAFTA countries consist of Canada, Mexico and the U.S.A. According to the Centre for Automotive Research, Mexico and Canada contribute to approximately 37% and 11% respectively of the U.S.' total automotive parts imports, as well as 24% and 22% respectively of its total finished vehicle imports. Excluding domestic producers in the U.S., the highest number of vehicles sold were those produced from Canadian and Mexican firms. Since the NAFTA countries' other main trading partners in the automotive sector are the European Union (EU) and Japan, these regions are aggregated separately for the study. All other countries are categorized as "the rest of the world".

The 57 categorized goods produced in the economy are aggregated under 10 categories: automotive parts and finished vehicles, manufacturing, metals, oil, coal, petroleum and coal products, machinery and equipment, road transport, agriculture, and services. The rest of sectors are aggregated as "the rest of the sectors." Because the automotive industry is closely related to the sectors of manufacturing, metals, machinery and equipment and road transport in terms of their intermediate inputs and proportion of skilled to unskilled labour, those four sectors are the most likely to experience shifts in the allocation of factors of production and are thus aggregated as such. Furthermore, agriculture is a significant sector for employment, as it forms 13% of the total employment in Mexico, according to the World Bank. The same applies for the services in the two other NAFTA countries and the EU, as it contributes over 70% to real GDP in most industrialized countries. Meanwhile, the other sectors of oil, coal, and petroleum and coal

products form a large proportion of exports from the perennial "swing states" (refer to section 4.2 on modified tariffs).

The factors of production are then aggregated into the standard five categories: capital, land, natural resources, and two types of labour, skilled and unskilled. Labour was separated into those categories as the proportion of factor income from both types of labour differs among different sectors and regions. In the automotive sector specifically, unskilled labour accounts for approximately 30% of factor income share and unskilled labour accounts for 20% and above of the factor income share in Canada, the EU and the U.S., while skilled labour is far less prominent in Mexico, where it accounts for only 3% of factor income share.

This study will simulate the effects of U.S imposed auto tariffs of 25% on automobile parts and finished vehicles. In order to do so, three simulations will be conducted: the implementation of tariffs with no retaliation, tariffs with retaliation back on the same automotive products, and tariffs with retaliatory measures directed at the top exports of politically significant states in the U.S (coal, oil and petroleum and coal products). Through all simulations, there is a study in the changes in prices, wages and macroeconomic performance. In the last simulation, a sensitivity analysis is applied and the elasticity doubled.

4. Descriptive Statistics and Calibration

4.1 Tariffs Structures

In order to understand the impacts of the U.S. tariffs on automotive imports, it is necessary to understand the current state of trade relationships within the NAFTA countries and with the EU. Because the version of GTAP used in the simulations is based on 2011 data, tariffs were updated to reflect 2018 values. Notable changes between 2011 and 2018 include the signing of the Canada-EU Free Trade Agreement (CETA) in 2016 and new updates to the

Mexico-EU Free Trade Agreement in 2018, in which nearly all traded goods between the EU Mexico will be duty-free (the only exceptions are select agricultural products which are not the focus of this paper.) It is important to note however, that the simulations are done before the implementation of aluminum and steel tariffs and their respective retaliatory measures in order to gauge the net effects of the U.S. auto import tariffs independently.

Tables 1a, 1b, 1c, and 1d display the tariff structures (as an Ad-Valorem Percent rate) on imports into Canada, Mexico, the United States and the European Union respectively. Because of the North American Free Trade Agreement, there are no tariffs on imports to most sectors in Canada, Mexico, and the U.S. However, because of certain sectoral tariff exemptions, some countries are allowed imposing tariffs to protect important domestic industries. For example, as shown in Table 1b, the Canadian government's supply management policy explains the higher import tariffs on agriculture. There are tariffs applied to Japan and countries in the category of "rest of world" as NAFTA is not a customs union.

Table 1a. Import Tariffs from Region X into the U.S.

	Canada	Mexico	EU	Japan	Rest of World
autoparts	0	0	2.5	1.2	0.833
roadtransprt	0	0	0.073	0.368	0.467
manufact	0	0	0.919	1.84	1.07
metals	0	0	1.21	1.63	1.05
machinequip	0	0	0.858	0.993	1.12
coal	0	0	0	0	0
petrol_coalp	0	0	1.61	1.25	0.924
oil	0	0	0.1	0	0.062
services	0	0	0	0	0
agriculture	0.193	0.02	4.58	1.25	1.03
rest	0.272	0.019	1.74	1.57	3.18

Source: Own aggregation of the GTAP model

Table 1b. Import Tariffs from Region X into Canada

	USA	Mexico	EU	Japan	Rest of World
autoparts	0	0	0	4.84	4.48
roadtransprt	0	0	0	0.127	1.23
manufact	0	0	0.001	2.98	2
metals	0	0	0	0.33	0.329
machinequip	0	0	0	0.346	0.55
coal	0	0	0	0	0
petrol_coalp	0	0	0	1	0.194
oil	0	0	0	0	0
services	0	0	0	0	0
agriculture	6.83	0.09	0.013	0.734	7.83
rest	2.49	0.381	0	1.68	3.88

Source: Own aggregation of the GTAP model

Table 1c. Import Tariffs from Region X into Mexico

	USA	Canada	EU	Japan	Rest of World
autoparts	0	0	0	4.52	15.3
roadtransprt	0	0	0	0.314	7.28
manufact	2.29	0	0	3.54	9.19
metals	0.045	0	0	4.15	4.81
machinequip	0.087	0	0	2.29	5.48
coal	0	0	0	0	0.038
petrol_coalp	0	0	0	2.53	2.61
oil	0	0	0	0	4.65
services	0	0	0	0	0.001
agriculture	0.473	0.242	0	0.572	7.63
rest	0.255	1.24	0	1.91	5.61

Source: Own aggregation of the GTAP model

Table 1d. Import Tariffs from Region X into EU

	USA	Canada	Mexico	Japan	Rest of World
autoparts	10	0	0	7.34	2.26
roadtransprt	0.742	0	0	3.04	0.422
manufact	0.921	0	0	1.74	1.23
metals	1.79	0	0	1.4	0.768
machinequip	1.29	0	0	1.94	1.02
coal	0	0	0	0	0
petrol_coalp	1.76	0	0	1.93	0.112
oil	0	0	0	0	0
services	0	0	0	0	0
agriculture	3.73	0	0	0.437	2.14
rest	2.48	0	0	3.05	2.84

Source: Own aggregation of the GTAP model

4.2 Modified Tariffs:

This study assesses the impacts of U.S. auto import tariffs through three scenarios: the implementation of harsh tariff structures without retaliation, with in-kind retaliation, and retaliation on politically significant exports of the U.S. In all scenarios, it is assumed that CETA and the Mexico-EU FTA remain as is and no tariffs are applied except for those by the U.S. and those imposed as retaliation back on U.S. imports. The first scenario assumes 25% tariffs apply to both automotive parts and finished vehicles without retaliation, while the second scenario assumes that Canada, Mexico, the EU and Japan apply retaliatory tariffs of 25% on automotive imports from the U.S. In comparison to other current and pending U.S. tariffs as of May 2018, the automotive tariffs affect the largest value of exports from the U.S.

Table 2: Comparison of Current, Pending and Potential U.S. Tariffs

Tariff	Status (as of May 31, 2018)	Value of Imports
Solar panels & washing machines	In effect	$10.3 billion
Steel and aluminum	In effect (some exemptions)	$44.9 billion
1,333 Chinese products	Implemented shortly after June 15, 2018	$46.2 billion
Automobiles and auto parts	Under investigation by Commerce Department	$261.6 billion

Source: Peterson Institute of International Economics

While the first two scenarios focus mainly on the trade dynamics with tariffs solely imposed the automotive sector, the third scenario assumes that the major exporters of automotive parts and finished vehicles impose retaliatory tariffs which target the main exports of perennial swing states in the United States which voted for the Republican party in the 2016 U.S. presidential election. According to the U.S. Energy Information Administration, the Republican states of Wyoming, West Virginia, Kentucky, and Pennsylvania are the top exporters of coal, while Texas and North Dakota are the top exporters of oil, and Louisiana's most valuable export in 2017 was petroleum and coal products. Given such, the retaliatory tariffs by Canada, Mexico, the EU and Japan are set to 25% on over $100 billion worth of coal, oil, and petroleum and coal products, a strategy which is consistent with the EU's threat of tariffs on up to $300 billion U.S goods in the event of auto tariffs and current Canadian retaliatory measures to steel and

aluminum tariffs which target U.S. exporters in key states in order to maximize the political pressure in the U.S. These retaliatory tariffs not only strategically target the important exports of Republican states but also target the products which the trading partners are able to impact, as they import a significant share of them. For example, according to the Thomson Reuters Eikon trade flows monitor and the U.S. Energy Information Administration, Canada and Mexico comprise of 47% of U.S. petroleum product imports by share of total imports in 2017, Japan comprises nearly 10% of U.S. coal import shares, and the EU imports 12% of U.S. crude oil (peaked at 2017 at approximately 2.2 million tonnes).

5. Results Analysis

5.1 U.S Imposed 25% Tariffs on Auto Imports with no Retaliation

The first simulation assumes the U.S. tariffs are imposed on all countries at a 25% rate for all automotive parts and finished vehicles, without retaliation. Free trade between Canada and Mexico, as well as free trade Canada and the EU (through CETA) remains. The default closure of GTAP is used, where labour is the fixed, endogenous variable.

Overall Trade Trends

Overall, the automotive sector's exports from and to the U.S. decreased, whereas for Canada and Mexico, there was trade diversion to the EU. This is due to the fact that there are no tariffs between Canada and EU (CETA) and Mexico and the EU, resulting in comparatively lower prices for goods between those regions as opposed to those exported to the U.S. However, there

is an overall decrease in imports to all countries because this increase in export sales through trade diversion is still offset by the loss of trade with the United States.

Table 3: Percent Change in Export Sales of Auto Parts From Importing Country (column) to Exporting Country (row)

	USA	Canada	Mexico	EU	Rest of World
USA	-42.13	-12.59	-13.61	-8.11	-7.54
Canada	-36.3	-4.11	-5.24	45.85	1.49
Mexico	-34.88	-2.01	-2.97	3.48	3.73
EU	-33.01	26.75	-6.5	-0.27	0.13
Rest of World	-34.14	-5.41	-6.48	-0.23	0.17

Market Price

Table 4: Percent Change in Consumer Price for Automotive Sector Commodities

USA	Canada	Mexico	EU	Rest of World
7.567	0.284	0.013	0.057	0.073

Consumer price increased for all 3 NAFTA countries and the EU in response to U.S. tariffs on auto imports, yet most significantly in the U.S. This is because the U.S. depends most on intermediate good imports in the world, as they accounted for 43% of total U.S. good imports. This dependence is particularly pronounced in the auto sector, where states such as Ohio, Indiana, Texas, Tennessee and Kentucky import a combined total of $15 billion in auto parts from its NAFTA partners. Tariffs imposed on each of those intermediate goods which contribute

enormously to the automotive sector of the U.S. would cause costs for firms to skyrocket, or moving production to less efficient domestic firms would also similarly increase costs. According to author Bernard Swiecki of the Centre for Automotive Research (2018), Mexican components such as engines and transmissions produced in Mexico are often less expensive than their U.S. counterparts because of lower Mexican labor costs. The cost advantage with trade is shown below in the table based on Generic $25,000 Vehicle Produced in Mexico for U.S. or European Markets.

Table 5: Total Per Vehicle Export Cost Advantages

Cost Advantages	Difference Between U.S. and Mexican Production for Vehicle Sold in the United States	Difference Between U.S. and Mexican Production for Vehicle Sold in Europe
Assembly plant labor	$600 less in Mexico	
Parts	$1,500 less in Mexico[a]	
Transportation to the market	$900 more to ship a vehicle from Mexico to the United States than to ship a U.S.-made vehicle internally	$300 more to ship a vehicle from Mexico to EU than to ship a vehicle from the United States to Europe
FTA tariff advantages	No tariff when shipped within NAFTA area	EU tariff of $2,500 on a U.S.-made vehicle, but no tariff on a Mexican vehicle[b]
Total cost advantage	$1,200 less costly to deliver Mexican-made vehicle than U.S.-made vehicle for final sale in the United States	$4,300 less costly to deliver Mexican-made vehicle than U.S.-made vehicle for final sale in Europe

Source: CRS, based on conversation with the author, Bernard Swiecki, The Growing Role of Mexico in the North American Automotive Industry (Ann Arbor, MI: Center for Automotive Research, 2016), p. 46

Since this simulation assumes fixed labour, the rising costs from inefficient production are passed on most to American consumers. The other NAFTA partners actually see the least increase in prices, as even though there are hiked costs for intermediate imports to the U.S., trade between Canada, Mexico, the EU and the rest of the world continues without an additional 25% import tariff. Similarly, the EU experiences a smaller increase in prices because European firms are still able to import and export auto parts to and from other countries, minimizing the impact of costlier trade of intermediate goods. This is evidenced by its increased export sales to the rest of the world (+0.13%) and Canada (+26.8%), shown in Table 3 above.

Wages

Table 6 shows how total wages adjust after the imposition of tariffs, assuming that labour is the fixed, endogenous variable. The increase in total wages in the U.S. is attributable to an increased demand for labour in the automotive sector, as quantity of domestic production increases in response to consumers substituting foreign imports for domestic products. However, given that demand for labour in more than 7 other sectors decreases, it is likely only wages in the automotive sector which increase. On the other hand, the EU experiences a total increase in wages not because of the automotive sector but because of other sectors such as the services, agriculture and capital goods (+1.7% total) which offset the harms to the automotive sector.

Table 6: Percent Change in Wages

	USA	Canada	Mexico	EU	Rest of World
UnSkLab	0.12	-0.53	-0.9	0.06	0.04
SkLab	0.05	-0.55	-1.22	0.06	0.07

Welfare

The varying demands for labour can be accounted for by resources being allocated differently. The efficiency of such allocations is one of the factors which determine the welfare of a country. Since the U.S. is imposing the tariffs on auto imports and protecting the currently less competitive domestic sector, its allocative efficiency is the lowest. Terms of trade and investment savings however, offset that and result in overall greater welfare for the U.S. The high terms of trade show that the value of U.S. exports increase relative to its imports, allowing the U.S. to purchase more imports for each unit exported. Welfare for other countries decreases, with that of Mexico decreasing the most due to low terms of trade (price of exports decrease by 0.13%) and that of the EU decreasing the least due to higher terms of trade (costs of exports rise).

Table 7: Changes in Macroeconomic Performance (in millions)

	Allocative Efficiency	Terms of Trade	Investment Savings	Total
USA	-9828	5164	5256	592
Canada	182	-2606	-126	-2550
Mexico	-151	-2893	134	-2910
EU	-965	996	-620	-589
Rest of World	996	694	-4370	-2680

5.2 U.S Imposed 25% Tariffs on Auto Imports with Reciprocal Tariffs

The second simulation used the same shocks as the prior simulation, only with the addition of retaliatory tariffs from Canada, Mexico, the EU and Japan of 25% on auto imports likewise. Free trade between Canada and Mexico, as well as free trade Canada and the EU (through CETA) remains. The default closure of GTAP is used, where labour is the fixed, endogenous variable.

Overall Trade Trends

Table 8: Change in Export Sales of Auto Parts from Exporting Region (rows) to Importing Region (columns)

	USA	Canada	Mexico	EU	Rest of World
USA	0	-55.01	-59.84	-58.46	-5.83
Canada	-44.8	0	28.66	25.56	-13.36
Mexico	-40.14	56.32	0	-5.43	-6.07
EU	-31.84	123.88	49.17	0	0.31
Rest of World	-32.73	67.72	49.76	1.75	0

As evidenced in Table 8, only the U.S. completely decreases trade with all other 3 regions. There is more trade diversion to Canada, Mexico and the E.U. as there are no tariffs in CETA and between the EU and Mexico for automotive imports. Despite this, there is an overall decrease in trade in all countries (refer to Table 9 below) because this increase in export sales through trade diversion is still offset by the loss of trade with the United States.

Table 9: Percent Change in Aggregate Imports into Region

USA	Canada	Mexico	EU	Japan	Rest of World
-37.02	-17.74	-18.49	-0.02	-3.78	-0.2

Market Price:

Table 10: Percent Change in Consumer Price of Automotive Sector Commodities

USA	Canada	Mexico	EU	Rest of World
7.77	10.3	5.62	0.34	0.19

Table 10 displays the percent change in market prices after the implementation of the 25% auto tariffs and reciprocal retaliatory tariffs of 25%. The auto tariffs and their respective retaliatory tariffs also on the automotive sector's imports have increased the price per unit of imported good from all countries. However, the impact is most notable in Canada, likely because trade is more important as indicated below in Table 11 by Canada's comparatively higher percent of trade to output.

Table 11: Quantity of Automotive Trade in Millions and Percent of Trade to Output

Country	Exports	Imports	Total Trade Quantity	%Trade to Output
USA	114258	215703	329961	53.36
Canada	56329	62224	11855300	118.43
Mexico	70801	34261	105062	96.24
EU	654104	505497	1159601	100.05

This demonstrates how the auto sector in North America is highly integrated, as auto parts can cross the NAFTA borders up to 8 times before being installed in a final assembly plant in either Canada, Mexico or the US (Wilson C.E., 2011). According to the National Highway Traffic Safety Administration, nearly all of the major automotive brands use a parts sourced from abroad, even if the vehicles are assembled in the United States. For example, the Chevrolet Suburban draws a larger share of its parts from Mexico than from the United States and Canada combined. The more important trade of these auto parts and vehicles is, the higher the price per unit of imported commodity, as shown by the higher prices in Canada (+3.13%), Mexico (+1.48%) and the US (+1.41%). However, it is notable that while trade of commodities from the auto sector is important in the EU (% trade to output is higher than the US), its price per unit of imported commodity did not increase as drastically. This may be because the EU's auto sector exports proportionally the least to the U.S. (as shown in Table 12 below) and thus, the price is not as affected by the tariffs imposed on auto parts going to and from the U.S.

Table 12: Quantity of Exports from NAFTA Region (rows) to Region X (columns) in Millions

	USA	Canada	Mexico	EU	Japan	Rest of World	Total
USA	40581	4505	3821	431206	9370	164620	654104
Canada	52451	0	1441	526	57.6	1854	56329
Mexico	51227	5065	0	4840	302	9368	70801

Wages

Table 13: Percent Change in Wages with Employment Fixed

	USA	Canada	Mexico	EU	Rest of World
UnSkLab	-0.21	-0.73	-0.9	0.17	0.11
SkLab	-0.28	-0.77	-1.15	0.18	0.15

Table 13 shows how wages adjust after the imposition of tariffs, assuming that labour is fixed. The total wages for skilled and unskilled workers increased in the EU, yet decreased in the 3 NAFTA countries. The slight increase in wages in the EU and decrease in wages in Canada and Mexico can be attributable to their respective changes in demand for labour. The demand for skilled and unskilled labour in the EU increased by 0.13% and 0.15% respectively, likely due to the trade diversion to the rest of the world as shown in Table 10. This increase in demand for labour is proportional to its approximate increase in wages. The opposite is true for Canada and Mexico, which are more heavily dependent on the U.S. given the integrated nature of the NAFTA networks for intermediate auto imports. The demand for both types of labour decreased significantly in Canada and Mexico, thus also decreasing the wages.

Table 14: Percent Change in Demand for Labour

	USA	Canada	Mexico	EU	Rest of World
UnSkLab	4.38	-20.1	-15.24	0.35	-0.02
SkLab	4.47	-20.06	-14.96	0.34	-0.07

The U.S. may appear as an exception, as its demand for unskilled and skilled labour increased, while its wages for both types of labour decreased (-0.17% and -0.24% respectively).This may be because while the demand for skilled and unskilled labour in the automotive sector may have increased, demand for labour decreased in other related sectors such as the petroleum and coal products and services. The decreased demand and therefore quantity of labour in other related sectors may have offset the gains in employment in the automotive sector, shown in Table 14. The decrease in demand for unskilled and skilled labour in the services (-0.17 and -0.07 respectively) is particularly detrimental, as the former sector employs over 70% of all workers in the U.S. economy. Other gains in sectors such as manufacturing and the metals are more significant, yet the sectors overall form a smaller share of contribution to total employment. That results in lower demand for employment overall, driving down wages for most workers in the U.S.

Table 15: Percent Change in Demand for Labour in U.S. Sectors

	autoparts	roadtransprt	manufact	metals	machinequip	coal
UnSkLab	4.39	0.02	0.38	0.74	0.05	0.09
SkLab	4.49	0.14	0.48	0.84	0.14	0.11

	petrol_coalp	oil	services	agriculture	rest	CGDS
UnSkLab	-0.03	0.16	-0.17	-0.06	0.2	-2.32
SkLab	0.06	0.18	-0.07	-0.03	0.28	-2.25

Welfare

Overall, the welfare in each country decreased, with the United States harmed most significantly and the EU benefiting. Welfare is determined by the three concepts of allocative

efficiency, terms of trade and investment savings. Allocative efficiency represents how optimal the distribution of goods and services is, based on consumer's preferences, where negative values represent a decrease in efficiency and positive values represent an increase in efficiency. Terms of trade is the ratio of an index of a country's export prices to an index of its import prices--a higher value indicates that the region's exports are more valuable relative to their imports, allowing them to purchase more imports for each unit they can export. With the imposed tariffs and reciprocal retaliatory tariffs, the U.S. has the highest loss of welfare due to its disproportionately negative allocative efficiency. This is because the tariffs take resources from more competitive sectors towards domestic automotive firms which would have not been as efficient without protection. The EU may have benefited from the tariffs and their likewise retaliation on the U.S. due to trade diversion to the rest of the world (refer to Table 8). This trade diversion thus increased its terms of trade, offsetting the negative allocative efficiency.

Table 16: Changes in Macroeconomic Performance (in millions)

	Allocative Efficiency	Terms of Trade	Investment Saving	Total
USA	-11251	-2649	3253	-10647
Canada	-3002	-1164	-90.4	-4257
Mexico	-1356	-1155	106	-2405
EU	-1296	3509	-276	1938
Rest of World	1532	1168	-2834	-134

5.3 U.S Imposed 25% Tariffs on Auto Imports with Politically Targeted Retaliatory Tariffs

The third simulation used the same shocks as the prior simulation, only with the retaliatory tariffs from Canada, Mexico and the EU on the largest exports of the perennial swing states which voted for the Republican Party in the 2016 Presidential Election. Free trade between Canada and

Mexico, as well as free trade Canada and the EU (through CETA) will remain. The default closure of GTAP is used, where labour is the fixed, endogenous variable. The elasticity of automotive products was also doubled in the simulation.

Overall Trade Trends

As evidenced in Table 17 below, automotive trade with the U.S. decreases across all regions, with the most occurring in the NAFTA countries where multiple instances of border crossing in the production process of vehicles create higher costs for imports than for other regions. The Canada-EU Free Trade Agreement explains the trade diversion from the EU and Canada to each other (+26.45 EU exports to Canada and +46.63 Canadian exports to EU). Canada, Mexico the EU also increase trade to the rest of world, likely countries such as Japan and South Korea, where exporting is relatively less expensive than when compared with that to the U.S.

Table 17: Change in Export Sales of Automotive Commodities from Exporting Region (rows) to Importing Region (columns)

	USA	Canada	Mexico	EU	Rest of World
USA	0	-12.67	-13.61	-7.94	-7.33
Canada	-36.07	0	-4.91	46.63	2.06
Mexico	-34.87	-2.11	0	3.65	3.95
EU	-33.1	26.45	-6.65	0	0.2
Rest of World	-34.3	-5.74	-6.74	-0.35	0.12

Market Price

The private consumption price for automotive commodities increases in all countries, most drastically in the U.S. However, the price increase in Mexico is nearly negligible. This may be explained by the decrease in world demand for Mexican cars (exacerbated by the doubled

elasticity), evident by the substantial decrease in production of automotive commodities (-18.07%). The reduced demand decreased the supplier price in Mexico (-0.74%) and thus resulted in a negligible increase in consumer price (the difference between the supplier and consumer price is due to taxes).

Table 18: Percent Change in Consumer Price of Automotive Sector Commodities

USA	Canada	Mexico	EU	Rest of World
7.56	0.26	0.01	0.08	0.11

Table 19: Percent Change in Supplier Price of Automotive Products

USA	Canada	Mexico	EU	Rest of World
1.28	-0.37	-0.74	0.17	0.15

The same explanation applies to Canada, where the supplier price decreases by approximately half as much as Mexico and its resulting market price is higher. It is important to note that the supplier price still increases, though Canadian production of automotive parts decreases by nearly 5% more than Mexico (suggesting lower world demand for Canadian automotive commodities.) This discrepancy may be because although demand and therefore production decreases more in Canada, supplier price still increases because the rental rate of capital for Canada is relatively higher than for Mexico (0.05%). Finally, the EU experiences a smaller increase in market prices than in Canada, despite having an increased supplier price, likely due to relatively lower taxes on the producer and/or consumer.

Wages

Table 20: Percent Change in Total Cost for Factors of Production

	USA	Canada	Mexico	EU	Rest of World
Land	-0.69	-1.04	0.47	0.16	-0.12
UnSkLab	0.13	-0.78	-1.05	0.03	0.08
SkLab	0.05	-0.8	-1.36	0.05	0.11
Capital	0.03	-0.85	-1.44	0.06	0.08
NatRes	-7.02	1.12	2.77	2.7	0.03

When labour is fixed and wages are able to adjust, it is evident that the total wages of the U.S. and EU increase, while they decrease in Canada and Mexico. The total wages of the U.S increases, fuelled primarily by the 10% increase in demand for both skilled and unskilled labour in the automotive sector. As a result of the tariffs, the domestic automotive industry becomes more competitive and expands, shifting capital and labour from other sectors such as that which products petroleum and coal products or coal, where labour demands decrease.

Table 21: Percent Change in Demand for Labour in U.S. Sectors

	Autoparts	Roadtransprt	Manufact	Metals	Machinequip	Coal
UnSkLab	10.52	-0.1	-0.27	0.9	-0.57	-4.1
SkLab	10.63	0.02	-0.17	0.99	-0.47	-4.09
Capital	10.65	0.05	-0.15	1.01	-0.45	-4.08

	Petrol_coalp	Oil	Services	Agriculture	Rest	CGDS
UnSkLab	-4.21	-1.08	-0.17	-0.4	-0.13	-2.01
SkLab	-4.12	-1.06	-0.07	-0.36	-0.05	-1.93
Capital	-4.1	-1.06	-0.05	-0.36	-0.03	-1.92

Notably, the wages for unskilled labour in the U.S. automotive sector increases twice as much as that of skilled labour (+0.13% compared to +0.5%) as the sector is more unskilled labour intensive.

As expected, Canadian and Mexican wages drop as a result of the hits to domestic producers of automotive commodities that would have been imported to the U.S. The decrease in export sales to the U.S. (-12.67% and -13.61% for Canada and Mexico export sales respectively) is damaging, given the U.S. is their main trading partner in the sector due to the tariff-free routes created through NAFTA. On the other hand, EU wages increase due to an increase in demand for labour in 7 sectors: manufacturing, coal, petroleum & coal products, oil, services, agriculture and capital goods, which offset marginal decreases in demand for labour in the automotive sector.

Table 22: Percent Change in Demand for Labour in EU Sectors

	Autoparts	Roadtransprt	Manufact	Metals	Machinequip	Coal
UnSkLab	**-1.3**	**-0.22**	**0.05**	-0.27	-0.04	2.49
SkLab	-1.32	-0.25	0.03	-0.28	-0.06	2.49

	Petrol_coalp	Oil	Services	Agriculture	Rest	CGDS
UnSkLab	1.69	0.07	0.08	0.06	-0.06	0.5
SkLab	1.67	0.07	0.06	0.06	-0.07	0.48

Welfare

Table 23: Changes in Macroeconomic Performance (in millions)

	Allocative Efficiency	Terms of Trade	Investment Savings	Total
USA	-10914	3169	4931	-2813
Canada	-734	-2610	-104	-3448
Mexico	-1094	-2449	149	-3393
EU	-865	2353	-560	928
Japan	-206	-1402	-256	-1863
Rest of World	2560	909	-4164	-695

As the country imposing the tariff, the U.S. experiences a "terms of trade gain." Since the U.S. is a large country (its imports and exports are a significant share in the world market for the product), their imposed tariffs drives down the export price of commodities from the automotive sector. Thus, the pre-tariff price at which the other nations can export automotive commodities to the U.S. declines. This allows the U.S. to import more for every unit it exports--hence, the terms of trade gain. However, the gains from this are outweighed by the enormous allocative efficiency losses, as the firms which previously were more efficient using imported parts now face rising costs with imports or less efficient operational costs domestically. Canada is harmed the most, mainly as its values of exports decrease relative to the value of its imports.

6. Conclusion

This paper evaluates the effects on wages, prices and overall welfare from the implementation 25% tariffs on automotive imports into the U.S. In particular, the study draws the attention of policy makers to the varying outcomes from different retaliatory measures taken

against the U.S., with a wide range of possibilities considered--no retaliation, reciprocal retaliation on the U.S. automotive exports and politically targeted retaliation.

In the first simulation, all countries face a decrease in net welfare except the U.S., which benefits as the large country implementing the tariffs without facing retaliation. However, wages decrease in Canada and Mexico. The EU on the other hand, slightly benefits from being spared from the worst harms of the tariff breaking up the highly integrated North American automotive sectors and its total wages benefit slightly. These trends are also nearly all true in the second and third simulation, the EU's welfare actually increases in the second simulation. The net macroeconomic performance of the U.S. decreases substantially due to the losses in allocative efficiency from the tariffs on imports and exports of automotive commodities. In the third simulation, only the EU marginally benefits overall, experiencing an increase in wages and better macroeconomic performance.

Overall in all simulations, consumers are harmed by spikes in prices for automotive commodities. Furthermore, total wages are generally hit for marginal benefits in the automotive sector. Across all simulations, the factors of wages and macroeconomic performance additionally showed that the EU is marginally affected compared to the NAFTA countries. Canada, Mexico and the U.S. experience the most harm given the interconnected networks developed by the automotive industry in the NAFTA region and the degree of harm to the U.S. depends on the type of retaliatory measures taken by the countries it imposes tariffs on. The retaliatory measures of 25% tariffs on U.S. exports of coal, oil and petroleum products in simulation 3 with doubled elasticity of automotive commodities proved to effect the most

damage to consumers who are faced with higher prices, to workers in majority of the largest industries such as the services with decreases in wages, and to the U.S.' overall macroeconomic performance.

7. Appendix

GTAP Description of Sectors and Aggregations

GTAP Description	Sector
Autoparts	Vehicles and parts
Roadtransprt	Transport equipment nec, transport nec
Manufact	Manufacturing
Metals	Ferrous metals, metals nec, metal products
Machinequip	Machinery and equipment nec
Coal	Coal
Petrol_coalp	Petroleum and Coal Products
Oil	Oil
Services	Communication, financial services nec, insurance, business services nec, recreation and other services, public administration, defence, health, education, dwellings
Agriculture	Paddy rice, wheat, cereal grains, vegetables, fruits, nuts, oil seeds, sugar cane, sugar beet, plant-based fibers, crops, animal products, raw milk
Rest	Wool, forestry, fishing, gas, minerals nec, meat products nec, sugar, food products nec, beverages and tobacco products, textiles, wearing apparel, leather products, wood products, paper products, chemical products nec, mineral products nec, electronic equipment
CGDS	Capital Goods Commodities

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