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Economic Impacts of the Possible China–US Trade War

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ABSTRACT: This article uses a multi-country global general equilibrium (GE) model to numerically simulate the effects of possible China–US trade wars. We introduce an endogenous trade imbalance structure with trade cost into the model which helps to explore both tariff and non-tariff trade war effects. Our simulation results show that China will be significantly hurt by the China–US trade war, but negative impacts are affordable. The US can gain under unilateral sanction measures to China, but will lose if China takes retaliation measures. Comparing the effects under mutual trade war, China will lose more than the US. Introducing non-tariff barrier trade wars will intensify the negative effects, and comparatively negative effects to China are larger than to the US. Mexico's involvement in trade war with the US will strengthen the negative effects and comparatively hurt the US more. Under non-cooperative and cooperative Nash bargaining equilibrium, the US can gain more than China in trade war negotiation, which means the US has stronger bargaining power than China. Additionally, trade wars between China and the US will hurt most countries and the world especially in GDP and manufacturing employment, but benefit their welfare and trade.

KEY WORDS: China, numerical general equilibrium, trade war, U.S.

JEL CLASSIFICATION: F51, C68, F13

China-US economic relations have expanded substantially over the past three decades, their mutual total merchandise trade rose from $2 billion in 1979 to $579 billion in 2016.[1] China now is the US' second-largest merchandise trading partner, third largest export market, and biggest source of imports. China-US mutual trade and investment relations benefit both countries, the US provides China a big exporting market, and the US imports of lower-cost goods from China greatly benefit US consumers. China is also the second-largest foreign holders of US Treasury securities, which helps US to keep interest rates low (Morrison 2017).

Despite growing economic relations and mutual dependence, China and the US bilateral disputes have become increasingly intensive. China criticizes the US of their export restrictions on high-technology products, their unfair treatments of China's market economy status, and unreasonable trade sanctions on China. Major areas of concern expressed by the US include large numbers of trade surplus, relatively ineffective record of enforcing intellectual property rights (IPR), discriminatory innovation policies, and mixed record on implementing WTO obligations. Although faced with gradually increasing commercial disputes, the China–US economic relations are positive and develop fast in general. But the harmonious situation seems to change after Donald Trump was elected to be the President of the US

Trump administration officials contend that the US should take a more aggressive stance against China's trade policies. In the presidential election period, Trump claimed to levy 45% punitive tariffs on imports from China, and levy 35% punitive tariffs on imports from Mexico. After Trump officially became the President, although severe trade wars had not happened, but trade bargaining in the fields

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of adjusting trade imbalance and foreign exchange rate was already in process. China–US trade war is not just a threat by Trump, it may occur in some conditions in the future. Even though the furious trade war between China and the US will not end happily, research on the effects of possible trade wars are still valuable and interesting from a policy perspective. Based on these backgrounds, this article numerically explores who can win the possible China–US trade war with the methodology of computational general equilibrium (CGE) modeling and simulation.

Literatures on China–US trade wars are limited and are mostly analytical. Ikenson (2017) analyzes the possibilities of China-US trade war at present stage. Lazard (2017) explores the China-US relations in the Trump era from the emerging market perspective. This article points out that Trump has started a willingness to slap a 45% tariff on imported Chinese goods and label China a currency manipulator for suppressing the value of the renminbi to boost its exports, and the article assumes that the ability of the US to impose such a tariff and the benefits of doing so are questionable. Morrison (2017) studies China-US trade and investment relations comprehensively and analyzes possible bilateral trade wars. Hughes and Meckling (2017) discuss the US-China Solar dispute. Schell and Chairs (2017) analyze the US policy toward China, and give recommendations for a new administration.

There are countable research papers exploring the effects of China–US trade wars empirically. Dong and Whalley (2012) use two closely related numerical general equilibrium models of world trade to analyze the potential consequences of US-China bilateral retaliation on trade flows and welfare. Results suggest that retaliation between the two countries can be welfare improving for the US as it substitutes expenditures into own goods and improve its terms of trade, while China may be adversely affected. Gompert, Cevallos, and Garafola (2016) explore the potential China–US wars and their military losses, economic costs, political effects, and international effects. Li (2017) uses a numerical general equilibrium methodology to explore the effects of bilateral trade retaliation on China, our simulation results suggest that China will be hurt by trade retaliation. But the background of these existing researches is not the present situation of China–US trade war at Trump era.

This article builds a 29-country global general equilibrium model to numerically simulate the potential effects of possible China–US trade wars. We introduce an endogenous trade imbalance structure and a trade cost structure into the GE model, which are good for the trade war research. We explore the effects of tariff trade wars, tariff along with non-tariff trade wars, China–US trade war plus Mexico–US trade war, and the Nash bargaining trade wars. Our simulation results are valuable on policy side.

Model and Computation of Nash Bargaining Equilibrium

We build a global general equilibrium model, introduce non-cooperative and cooperative Nash equilibrium tariff war calculation methodology, and present the data and parameters calibration process in this part. We can get a numerical global GE model after these treatments.

An Endogenous Trade Imbalance GE Model

We assume $M = \{1, 2, \cdots, m\}$ countries for each produce $N = \{1, 2, \cdots, n\}$ goods with $T = \{1, 2, \cdots, t\}$ factors model framework. Production functions are CES technology of each good in each country

$$Q_i^l = \phi_i^l \sum_s [\delta_{is}^l (F_{is}^l)^{\frac{\sigma_i^l - 1}{\sigma_i^l}}]^{\frac{\sigma_i^l}{\sigma_i^l - 1}}, i = country, l = goods, s = factor. \tag{1}$$

where Q_i^l is the output of the *lth* industry in the country *i*, F_{is}^l is the factor *s* input in the sector *l* of country *i*, ϕ_i^l are the scale parameters, δ_{is}^l are the distribution parameters, and σ_i^l is the elasticity of factor substitution. First-order conditions subject to the endowment constraints imply the factor input demand equations.

Consumption functions for each country are a nested CES utility function. We use the Armington assumption of product heterogeneity across countries. For simplicity, we consume a two goods situation, which are tradable goods and non-tradable goods, so the first level utility function is

$$U_i(X_i^T, X_i^{NT}) = [\alpha_{i1}^{\frac{1}{\sigma_i}}(X_i^T)^{\frac{\sigma_i-1}{\sigma_i}} + \alpha_{i2}^{\frac{1}{\sigma_i}}(X_i^{NT})^{\frac{\sigma_i-1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i-1}},\ i = country. \tag{2}$$

where X_i^{NT} denotes the consumption of non-tradable goods in the country i, and X_i^T denotes the consumption of composite Armington tradable goods in the country i. Additionally α_{i1} and α_{i2} are share parameters and σ_i is the top-level elasticity of substitution in consumption.

The composite of tradable goods is defined by the other consumption level reflecting the country from which goods come. We assume that this level 2 composite consumption is of CES form and represented as,

$$X_i^T = [\sum_j \beta_{ij}^{\frac{1}{\sigma_i'}} x_{ij}^{T\,\frac{\sigma_i'-1}{\sigma_i'}}]^{\frac{\sigma_i'}{\sigma_i'-1}},\ j = country. \tag{3}$$

where x_{ij}^T is the consumption of tradable goods from the country j in country i. If $i = j$ this denotes that this country consumes its domestically produced tradable goods. β_{ij} is the share parameter for country $j's$ tradable goods consumed in the country i. σ_i' is the elasticity of substitution in level 2 preferences in the country i.

We assume a representative consumer in the country i with money as $\overline{M}_i$. The budget constraint for this consumer's consumption is

$$P_i^T X_i^T + pc_i^{NT} X_i^{NT} = \overline{M}_i. \tag{4}$$

We solve the above utility optimization problem and yield

$$X_i^T = \frac{\alpha_{i1}\overline{M}_i}{(P_i^T)^{\sigma}[\alpha_{i1}(P_i^T)^{1-\sigma} + \alpha_{i2}(pc_i^{NT})^{1-\sigma}]}. \tag{5}$$

$$X_i^{NT} = \frac{\alpha_{i2}\overline{M}_i}{(pc_i^{NT})^{\sigma}[\alpha_{i1}(P_i^T)^{1-\sigma} + \alpha_{i2}(pc_i^{NT})^{1-\sigma}]}. \tag{6}$$

where P_i^T and pc_i^{NT} are separately consumption prices of composite tradable goods and non-tradable goods and inside money in the country i. For the composite of tradable goods, they enter the second-level preferences and come from different countries, and the country-specific demands are

$$x_{ij}^T = \frac{\beta_{ij}(X_i^T P_i^T)}{(pc_{ij}^T)^{\sigma_i'}[\sum_j \beta_{ij}(pc_{ij}^T)^{(1-\sigma_i')}]}. \tag{7}$$

where pc_{ij}^T is the consumption price in the country i of tradable goods produced in the country j, $X_i^T P_i^T$ is the total expenditure on tradable goods in the country i. The consumption price for the composite of tradable goods is

$$P_i^T = [\sum_{j=1}^{5} \beta_{ij}(pc_{ij}^T)^{(1-\sigma_i')}]^{\frac{1}{1-\sigma_i'}}. \tag{8}$$

Equilibrium in the model then characterized by market clearing prices for goods and factors in each country such that

$$Q_i^T = \sum_j x_{ji}^T. \tag{9}$$

$$\sum_l F_i^l = \overline{F_i}. \tag{10}$$

A zero profit condition must also be satisfied in each industry, such that

$$p_i^l Q_i^l = w_i^K K_i^l + w_i^L L_i^l \; l = T, NT. \tag{11}$$

where p_i^l is the producer price of goods l in country i.

We introduce trade costs for trade between countries. Trade costs include not only import tariffs but also other non-tariff barriers such as transportation costs, language barriers, and institutional barriers. We divide trade costs into two parts in our model, which are import tariff and non-tariff trade costs. We denote the import tariff in the country i as t_i, and non-tariff trade costs as N_{ij} (ad volume tariff-equivalent non-tariff trade costs for country i imported from the country j). This yields the following relation of consumption prices and production prices in the country i for country $j's$ exports.

$$pc_{ij}^T = (1 + t_i + N_{ij}) p_j^T. \tag{12}$$

Import tariffs will generate revenues R_i, which are given by

$$R_i = \sum_{j, i \neq j} p_j^T x_{ij}^T t_i. \tag{13}$$

For non-tariff trade costs, they are different from the import tariff: they cannot collect revenue, and importers need to use actual resources to cover the costs involved. In the numerical model, we assume that the resource costs involved in overcoming all other non-tariff barriers are denominated in terms of domestic non-tradable goods. We incorporate this resource using feature through use of non-tradable goods equal in value terms to the cost of the barrier. We thus assume reduced non-tariff trade costs (including transportation cost) will thus occur under trade liberalization as an increase in non-tradable goods consumption NR_i by the representative consumer in importing countries. The representative consumer's income in country i is thus given by

$$w_i^K \overline{K_i} + w_i^L \overline{L_i} + R_i = I_i. \tag{14}$$

and the demand-supply equality involving non-tradable goods becomes

$$Q_i^{NT} = \frac{NR_i}{p_i^{NT}} + X_i^{NT}. \tag{15}$$

where

$$NR_i = \sum_{j, i \neq j} p_j^T x_{ij}^T N_{ij}. \tag{16}$$

To accommodate a trade surplus or deficit as an endogenous variable in the model structure, we use a monetized extension of this structure incorporating a fixed exchange rate and non-accommodative monetary policy following Whalley and Wang (2010). If we only consider the transactions demand for money in each country and for simplicity assume unitary velocity, the money demand will equal all

transaction values in one country. In our model, it equals all consumption values of tradable goods and non-tradable goods.

In traditional models, money is neutral in the sense that once domestic money supplies are specified, an equilibrium exchange rate is determined independently of the real side, and a fixed exchange rate regime and trade imbalance does not occur. And if the exchange rate is fixed, then the relative domestic money stocks need to accommodate so as to support it as an equilibrium exchange rate. In the structure we use, the monetary regime is non-accommodative to the fixed exchange rate; and in this case the trade surplus or deficit will be endogenously determined by the equation

$$S_i = I_i - \overline{M}_i \tag{17}$$

where S_i is trade surplus for country i. Once money supply in country i has been fixed, then the trade imbalance for country i will be endogenously determined. Global trade clearance determines that all of countries' trade should be balanced, which is

$$\sum_i S_i = 0 \tag{18}$$

We add these conditions in the global GE model yielding an endogenous monetary trade imbalance general equilibrium model structure.

Solutions of Non-Cooperative and Cooperative Nash Bargaining Equilibrium

Tariff war is one kind of trade bargaining in essence. We will calculate the non-cooperative and cooperative Nash bargaining equilibrium and analyze the trade war effects under these equilibriums. Meanwhile, we will compare the gains of trade war involved counties when moving from non-cooperative Nash equilibrium to cooperative Nash equilibrium, and these comparative gains will show the comparative bargaining power of the trade war involved countries.

The non-cooperative Nash equilibrium is a solution to tariff war game which is formulated by Nash (1950). It is a solution concept of a non-cooperative game involving two or more players in which each player is assumed to know the equilibrium strategies of the other players, and no player has anything to gain by changing only his or her own strategy. If each player has chosen a strategy and no player can benefit by changing strategies while the other players keep theirs unchanged, then the current set of strategy choices and the corresponding payoffs constitutes a Nash equilibrium.

Nash's cooperative bargaining equilibrium is as follows: Two agents have access to any of the alternatives in a set, called the feasible set. Their preferences over these alternatives differ. If they agree on a particular alternative, that is what they get. Otherwise, they end up at a prespecified alternative in the feasible set, called the disagreement point. Both the feasible set and the disagreement point are in utility space. Let them be given by S and d respectively. Nash's objective was to help to predict the compromises that agents would reach. He specified a class of bargaining problems which conformed to his analysis, and he defined a solution to be a rule that associates with each (S, d) in the class a point in S, and interpreted this as the compromise. He formulated a list of properties, or axioms, that he thought solutions should satisfy (Thomson 1994).

Specifically, the cooperative Nash equilibrium is obtained by maximizing the product of utility gains relative to the disagreement point, that is, N(S, d) is the maximization of

$$Max \prod (X_i - d_i)\ X \in S, X \geq d. \tag{19}$$

where X_i is the NBS utility of individual i, d is the disagreement point, and d_i is the disagreement utility for individual i.

In computing non-cooperative equilibria with our numerical general equilibrium model, we adopt Nash's (1951) non-cooperative solution concept. In the five-country general equilibrium model, the method for computing non-cooperative Nash equilibrium is to iterate over calculations of optimal tariffs by individual countries, which are

$$Max(u_i)\ s.t.\ GE\ i = country. \tag{20}$$

where GE denotes a five country complete general equilibrium. We use Equation (11) to obtain convergence to a Nash equilibrium.

After computing non-cooperative equilibrium tariffs, we can determine the disagreement point and then simulate the utilities possibilities frontier under cooperation, and apply the Nash bargaining criterion

$$Max \prod (u_i - d_i)\ s.t\ GE\ i = A, B. \tag{21}$$

to obtain the cooperative Nash bargaining equilibrium.

Data and Parameters Calibration

We use 2013 as our base year in building a benchmark numerical general equilibrium dataset for use in calibration and simulation. We include 29 countries in our numerical model, which are Australia, Bahrain, Brazil, Brunei, Canada, Chile, China, EU (Europe Union), India, Indonesia, Japan, Korea, Kuwait, Malaysia, Mexico, New Zealand, Oman, Papua New Guinea, Peru, Philippines, Qatar, Russian, Saudi Arabia, Singapore, Thailand, United Arab Emirates, US (United States), Vietnam, and ROW (rest of world). Production factors in our numerical models include capital (K) and labor (L). We include only two goods in our model structures, which are tradable goods and non-tradable goods.

EU data are from EU statistics, and the currency unit is Euro, we use the annual average exchange rate to change them into US dollar; Other countries' data are all calculated from WDI of World Bank database. We use agriculture and service share of GDP data and GDP data to yield production data of tradable goods and non-tradable goods and use capital/GDP ratio to yield capital and labor input in production. We use world values minus all individual countries to generate ROW values. For the two goods, we assume that secondary industry (manufacturing) reflects tradable goods, and primary and tertiary industries (agriculture, extractive industries, and services) yield non-tradable goods. For the two factor inputs, we use total labor income (wage) to denote labor values for inputs by sector. All data are in billion US dollars. We adjust some of the data values for mutual consistency for calibration purposes. Trade data between each pair of countries are from the UN Comtrade database. We use individual country total export and import values to indirectly yield exports to and imports from the ROW. Using production and trade data, we can then calculate each country's consumption values.

Trade cost calculation methodology is based on Novy (2013) and Wong (2012), their method is to take the ratio of bilateral trade flows over local trade, scaled to some parameter values, and then use a measure that capture all barriers. In the trade cost calculation, all trade data are from the UN Comtrade database and World Development Indicators (WDI) of World Bank database.

We divide trade costs into two parts, import tariffs and all other non-tariff barriers. We obtain each country's import tariff data from WTO Statistics Database. For ROW, we cannot obtain its import tariff directly, and so we use world average tariff rate to denote its value. We calculate all other non-tariff barriers by using trade costs minus import tariffs.

There are no available estimates of elasticities for individual countries on the demand and production sides of the model. Many of the estimates of domestic and import goods substitution elasticity are around 2, so we set all these elasticities in our model to 2 (Whalley and Wang 2010). We change these elasticities later in sensitivity analysis to check their influence on simulation results.

With these data, we calibrate the model parameters with GAMS software. When used in model solution these will regenerate the benchmark data as an equilibrium for the model. Then, using these parameters we can simulate the effects of trade wars.

Effects of Possible China–US Trade Wars

According to the reality of the possible China–US trade wars, we set up five different scenarios to explore their effects to China, the US, and other countries. The impacts to China and the US are our main focus of attention. These five scenarios are: (1) China–US tariff trade war, we will analyze the US's unilateral tariff measures and mutual retaliation tariff measures; (2) China–US tariff along with non-tariff barrier trade war, both countries will take measures with both tariff and non-tariff barriers; (3) China–US tariff war along with Mexico–US tariff war, as Trump had ever said that he will levy import tariff to Mexico products; (4) non-cooperative Nash bargaining equilibrium tariff war, which explores the impacts of trade war under the non-cooperative Nash equilibrium optimal level; (5) cooperative Nash bargaining equilibrium, which explores both the loss compared with benchmark and the loss compared with non-cooperative Nash equilibrium.

China–US Tariff Trade War

Tariff trade war is a basic protection and retaliation measures, it can be an overall import tariff to all imported products from a specific country, and also can be a targeted import tariff to a specific imported product from a specific country. We assume overall import tariff trade war between China and the US. In order to give a full picture of tariff war effects, we use four different tariff levels to separately simulate their impacts. These four different import tariff levels are separately 15%, 30%, 45%, and 60%, we consider both unilateral one-side tariff measures taken by the US to China, and bilateral mutual import tariff measures taken by both the US and China with the same import tariff level.

We firstly analyze the effects on China. Simulation results show that China will be significantly hurt by tariff trade war in all indicators, including welfare, gross domestic product (GDP), manufacturing employment and trade. Within them, trade effects are prominent, production and employment effects are moderate, and welfare effects are comparatively weak. The positive effect on non-manufacturing production is because of the full employment assumption in the model, so the manufacturing production decrease will cause the non-manufacturing increase. The negative effects on China are affordable even though the import tariffs by the US to China are big, which means trade wars will not hurt China's economy severely. Compared with unilateral tariff measures by the US, China's retaliation will decrease its loss, so tariff retaliation to the US is a preferential strategy to China. The negative effects of tariff war on China are positively related with import tariff level. Meanwhile, China's tariff retaliation to the US will hurt the US more than the situation without retaliation (see Table 1).

We take the mutual tariff war with 45% import tariff rate as an example to specifically show the effects to China. Welfare, GDP and trade will separately decrease by −0.441%, −1.514%, and −5.960%. Manufacturing production and employment will separately decrease by −3.955% and −2.479%. Export and import will separately decrease by −7.993% and −3.502%. But non-manufacturing production will increase 0.533% (see Table 1).

We secondly analyze the effects on the US. Simulation results show that the US will gain on welfare, GDP and non-manufacturing production, but hurt employment and trade (both export and import). When China do not take retaliation measures, the US will gain on manufacturing production; but when China take retaliation measures, manufacturing production of the US will decrease. Comparatively, trade effects are larger than production effects, and the production effects are more prominent than welfare effects. As the import tariff rates increase, trade war effects to the US will increase in the beginning but decrease later. If China take retaliation measures to the US, the US' gains will decrease but losses will increase. The main purpose for the US to initiate trade war is to increase employment, but our simulation results prove that the US actually cannot increase its employment (see Table 1).

Table 1. The effects of China–US tariff trade war on China and the US (unit: percent change %).

Country	Welfare	GDP	M	NM	Employ	Trade	Export	Import
Unilateral 15% tariff measures by the US								
China	−0.179	−0.724	−1.750	0.137	−1.034	−2.082	−3.394	−0.496
US	0.139	0.125	0.051	0.146	−0.074	−2.125	−0.217	−3.480
Mutual trade war with the same level of 15% tariff measures								
China	−0.163	−0.667	−1.721	0.217	−1.062	−2.601	−3.467	−1.554
US	0.120	0.007	−0.538	0.161	−0.545	−2.749	−1.583	−3.577
Unilateral 30% tariff measures by the US								
China	−0.312	−1.260	−3.047	0.239	−1.810	−3.626	−5.909	−0.867
US	0.184	0.241	0.096	0.282	−0.144	−3.689	−0.397	−6.027
Mutual trade war with the same level of 30% tariff measures								
China	−0.310	−1.152	−2.992	0.391	−1.861	−4.514	−6.036	−2.673
US	0.152	0.037	−0.920	0.308	−0.957	−4.761	−2.750	−6.189
Unilateral 45% tariff measures by the US								
China	−0.414	−1.667	−4.033	0.317	−2.407	−4.803	−7.824	−1.152
US	0.175	0.346	0.136	0.406	−0.210	−4.871	−0.546	−7.941
Mutual trade war with the same level of 45% tariff measures								
China	−0.441	−1.514	−3.955	0.533	−2.479	−5.960	−7.993	−3.502
US	0.132	0.079	−1.200	0.440	−1.278	−6.276	−3.638	−8.149
Unilateral 60% tariff measures by the US								
China	−0.493	−1.983	−4.801	0.378	−2.875	−5.720	−9.314	−1.375
US	0.133	0.442	0.171	0.519	−0.270	−5.783	−0.673	−9.412
Mutual trade war with the same level of 60% tariff measures								
China	−0.559	−1.790	−4.703	0.651	−2.965	−7.079	−9.517	−4.132
US	0.083	0.126	−1.409	0.559	−1.533	−7.442	−4.330	−9.652

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

We take the mutual tariff war with 45% import tariff rate as an example to specifically show the effects to the US. Welfare, GDP and non-manufacturing production will separately increase by 0.132%, 0.079% and 0.44%. Manufacturing production and employment will separately decrease by −1.2% and −1.278%. Trade, export, and import will separately decrease by −6.276%, −3.638%, and −8.149% (see Table 1).

Comparing the effects on China and the US, although the US will lose in some aspects but can gain in some indicators, so the US is willing to initiate China–US trade war. But China will be hurt on all indicators so China may not want to be involved in trade wars with the US. In general, both the US and China will lose in the tariff war, but comparatively China will lose more than the US.

We then analyze the effects on other countries out of the China–US tariff trade war. Simulation results show that most other countries will gain on welfare and trade, but lose on production and employment. The reason for these results is that trade war between China and the US decreased trade between them, but increase trade with other countries. The effects are increasing as import tariff rate in trade war increase. Meanwhile, the effects to small countries and high trade dependence countries are more significant (see Table 2).

The effects of China–US tariff war to the world are negative. World total welfare, GDP, manufacturing production and employment, export, import, and total trade also decrease. The increased non-manufacturing production is because of our full employment assumption in the model, so manufacturing production decrease will increase the non-manufacturing production. The negatively effects to the world are positively related with import tariffs. We take the 60% mutual import tariff trade war as an example, the world total welfare, GDP, manufacturing employment, and trade will separately decrease by −0.015%, −0.277%, −0.655%, and −1.911% (see Table 2).

Table 2. The effects of China–US tariff trade war on countries other than China and the US (unit: percent change %).

	Welfare	GDP	M	NM	Employ	Trade	Export	Import	Welfare	GDP	M	NM	Employ	Trade	Export	Import
Country	Mutual trade war with the same level of 15% tariff measures								Mutual trade war with the same level of 60% tariff measures							
China	−0.163	−0.667	−1.721	0.217	−1.062	−2.601	−3.467	−1.554	−0.559	−1.790	−4.703	0.651	−2.965	−7.079	−9.517	−4.132
US	0.120	0.007	−0.538	0.161	−0.545	−2.749	−1.583	−3.577	0.083	0.126	−1.409	0.559	−1.533	−7.442	−4.330	−9.652
EU	0.018	−0.024	−0.041	−0.016	−0.018	0.039	−0.029	0.113	0.048	−0.057	−0.091	−0.041	−0.034	0.126	−0.031	0.295
Japan	0.026	−0.044	−0.096	−0.024	−0.052	0.051	−0.029	0.123	0.071	−0.110	−0.229	−0.063	−0.119	0.164	−0.020	0.328
Korea	0.045	−0.102	−0.162	−0.040	−0.057	0.010	−0.027	0.052	0.122	−0.261	−0.406	−0.109	−0.140	0.049	−0.034	0.141
Canada	0.013	−0.006	0.002	−0.010	0.008	0.122	0.220	0.029	0.027	0.023	0.103	−0.019	0.080	0.386	0.737	0.054
Australia	0.014	−0.084	−0.212	−0.015	−0.128	−0.002	−0.087	0.086	0.036	−0.222	−0.560	−0.040	−0.339	0.006	−0.205	0.222
New Zealand	−0.083	−0.299	−0.523	0.035	−0.224	−0.001	0.188	−0.098	−0.228	−0.803	−1.407	0.097	−0.608	0.006	0.550	−0.272
Singapore	0.014	−0.108	−0.196	−0.019	−0.095	0.007	−0.012	0.025	0.035	−0.283	−0.516	−0.047	−0.252	0.025	−0.014	0.064
India	0.022	−0.065	−0.172	−0.018	−0.107	0.033	0.004	0.055	0.058	−0.169	−0.444	−0.048	−0.276	0.103	0.046	0.145
Russia	0.016	−0.058	−0.116	−0.012	−0.058	0.016	−0.011	0.059	0.042	−0.152	−0.303	−0.032	−0.151	0.054	−0.009	0.156
Brazil	0.011	−0.054	−0.162	−0.009	−0.108	0.015	−0.039	0.067	0.026	−0.141	−0.421	−0.022	−0.281	0.053	−0.062	0.165
Mexico	0.019	−0.014	−0.016	−0.012	−0.002	0.131	0.241	0.027	0.043	0.006	0.044	−0.024	0.037	0.413	0.791	0.056
Indonesia	0.020	−0.114	−0.168	−0.011	−0.054	0.042	0.013	0.068	0.053	−0.301	−0.443	−0.030	−0.142	0.130	0.074	0.181
Malaysia	0.004	−0.204	−0.240	−0.030	−0.023	0.057	0.109	0.009	0.012	−0.535	−0.629	−0.081	−0.060	0.171	0.329	0.026
Philippine	−0.042	−0.239	−0.395	0.006	−0.156	0.028	0.133	−0.028	−0.116	−0.638	−1.056	0.019	−0.420	0.088	0.410	−0.083
Thailand	−0.009	−0.176	−0.251	0.009	−0.070	0.032	0.078	−0.005	−0.025	−0.462	−0.658	0.024	−0.185	0.102	0.245	−0.012
Vietnam	0.009	−0.298	−0.328	−0.044	−0.016	0.112	0.260	0.008	0.030	−0.788	−0.866	−0.119	−0.043	0.323	0.753	0.023
Peru	−0.084	−0.276	−0.396	0.017	−0.121	0.020	0.236	−0.089	−0.235	−0.737	−1.059	0.047	−0.325	0.068	0.702	−0.253
Brunei	0.099	−0.098	−0.101	−0.074	−0.009	−0.015	−0.052	0.059	0.259	−0.255	−0.265	−0.181	−0.015	−0.038	−0.129	0.150
ROW	0.044	−0.046	−0.077	−0.030	−0.029	0.009	−0.049	0.071	0.120	−0.111	−0.173	−0.080	−0.059	0.043	−0.093	0.188
World	−0.021	−0.114	−0.419	0.051	−0.239	−0.709	−0.709	−0.709	−0.015	−0.277	−1.114	0.178	−0.655	−1.911	−1.911	−1.911

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

China–US Tariff Along with Non-Tariff Trade War

Trade war measures are not only tariffs, a lot of non-tariff trade protection measures are also often used, like the technical barriers to trade, standard barriers, environmental barriers, intellectual property barriers and so on. In this part, we numerically explore the impacts of China–US tariff along with non-tariff trade wars, which means that tariff measures and non-tariff measures are implemented at the same time by this two countries. We call this kind of war as trade cost war. Our 29-region numerical GE model has already introduced both tariff and non-tariff barriers, so the measures in trade war are extra tariff and non-tariff barrier measures. We sequentially give 15%, 30%, 45%, and 60% tariff and non-tariff barriers into the trade war assumption, and include both one-side unilateral trade war and mutual trade war in the simulation.

Effects on China are nearly the same as the simulation results in pure tariff war. China will be negatively influenced by trade cost war from the US, trade effects (especially export effects) are more significant than production and employment effects, and production effects are more significant than welfare effects. Negative impacts to China are positively related with tariff and non-tariff rates in trade wars. Mutual trade war will hurt China more compared with the unilateral trade war, which means that trade retaliation is not a good countermeasures for China under trade cost trade wars. But China's retaliation will give more negative impacts on the US (see Table 3).

We take the 45% mutual trade cost war as an example to explore China's specific loss. China's welfare, GDP and manufacturing employment will separately decrease by −0.325%, −1.21%, and −1.763%. Trade, export, and import will separately decrease by −3.613%, −5.852%, and −0.907%.

Table 3. The effects of China–US trade cost war on China and the US (unit: percent change %).

Country	Welfare	GDP	M	NM	Employ	Trade	Export	Import
Unilateral 15% both tariff and non-tariff measures by the US								
China	−0.325	−1.210	−2.952	0.250	−1.763	−3.613	−5.852	−0.907
US	−0.350	0.496	0.065	0.618	−0.429	−3.677	−0.543	−5.902
Mutual trade war with the same level of 15% trade cost measures								
China	−0.563	−1.000	−2.934	0.621	−1.953	−4.513	−6.051	−2.654
US	−0.387	0.301	−0.923	0.647	−1.221	−4.751	−2.872	−6.086
Unilateral 30% both tariff and non-tariff measures by the US								
China	−0.512	−1.915	−4.669	0.394	−2.808	−5.706	−9.241	−1.433
US	−0.630	0.809	0.127	1.002	−0.677	−5.770	−0.883	−9.241
Mutual trade war with the same level of 30% trade cost measures								
China	−0.917	−1.577	−4.622	0.975	−3.093	−7.080	−9.541	−4.104
US	−0.684	0.503	−1.412	1.045	−1.906	−7.429	−4.502	−9.508
Unilateral 45% both tariff and non-tariff measures by the US								
China	−0.630	−2.360	−5.755	0.485	−3.477	−7.024	−11.374	−1.764
US	−0.853	1.022	0.180	1.260	−0.833	−7.064	−1.112	−11.291
Mutual trade war with the same level of 45% trade cost measures								
China	−1.158	−1.939	−5.680	1.196	−3.814	−8.674	−11.734	−4.975
US	−0.917	0.647	−1.698	1.310	−2.330	−9.077	−5.520	−11.602
Unilateral 60% both tariff and non-tariff measures by the US								
China	−0.709	−2.660	−6.485	0.546	−3.930	−7.906	−12.802	−1.986
US	−1.034	1.175	0.226	1.443	−0.938	−7.914	−1.276	−12.627
Mutual trade war with the same level of 60% trade cost measures								
China	−1.332	−2.181	−6.385	1.343	−4.298	−9.730	−13.201	−5.533
US	−1.104	0.755	−1.875	1.497	−2.610	−10.157	−6.202	−12.965

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

Non-manufacturing production will increase by 1.196%, which is because of full employment assumption in the model and decreased manufacturing production (see Table 3).

Effects to the US are also the same as the results in pure tariff wars. The US can gain on production, but lose on welfare, manufacturing employment, and trade. Trade effects (especially import effects) are more prominent than production and employment effects, and production effects are more prominent than welfare effects. As trade cost rates increase in the war, the US will lose more. China's retaliation will also hurt the US more. Comparatively, losses of the US are less than China (see Table 3).

We take the 45% mutual trade cost war as an example to explore the US's detailed gains and losses. GDP and non-manufacturing production will separately increase by 0.647% and 1.31%. Welfare and manufacturing employment will separately decrease by −0.917% and −2.33%. Trade, export, and import will separately decrease by −9.077%, −5.52%, and −11.602% (see Table 3).

Comparison of the effects on both China and the US reveal that China will be hurt more than the US, but when China retaliates the US with the same level measures, their losses are close. The US' GDP can gain from trade war which is caused by decreased trade imbalance, but manufacturing employment cannot gain which may not fulfill the purpose of the US to initiate trade cost wars.

Comparing the effects on China and the US under tariff trade wars and trade cost wars, we find that trade cost wars will definitely generate stronger impacts to both countries. We take 45% tariff and trade cost wars as examples, and find that China's welfare losses will change from −0.441% to −1.158%, and trade losses will change from −5.96% to −8.674%; meanwhile the US' welfare losses will change from 0.132% to −0.917%, and trade losses will change from −6.276% to −9.077% (see Figure 1).

Effects on other countries out of trade wars find that most countries will gain on welfare and trade, but lose on production and employment. But compared with simulation results of pure tariff war, the negative effects on some indicators are less. China–US trade cost wars will benefit other countries which are not involved in the trade war (see Table 4).

Effects to the world as a whole are all negative, and are positively related with trade cost rates in the trade war. Therefore trade wars are one kind of trade protection measures and so will hurt the world. We take the 60% trade cost rate war as an example, the world welfare, GDP, manufacturing employment and trade will separately decrease by −0.37%, −0.087%, −0.835%, and −2.606% (see Table 4).

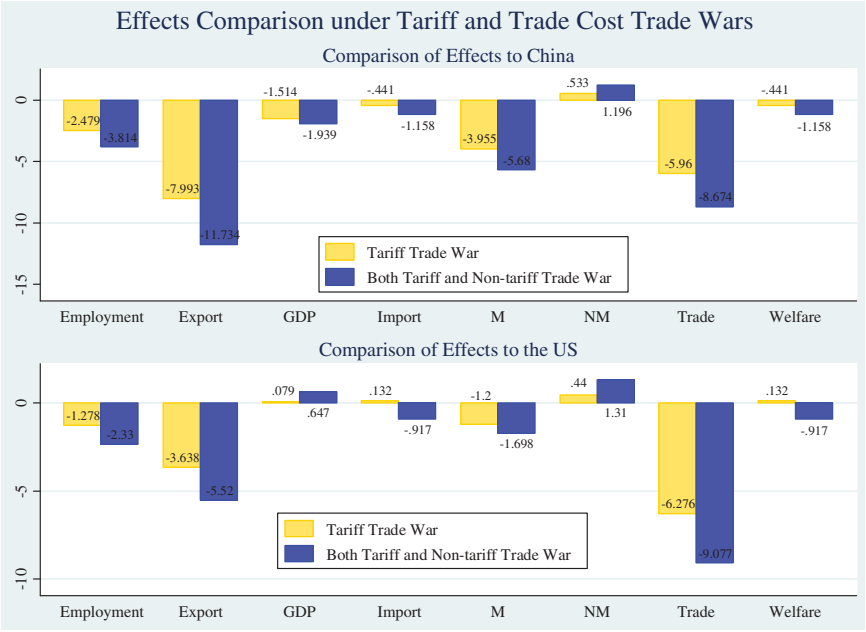

Figure 1. Effects comparisons between tariff and trade cost trade wars (unit: % change).
Source: By authors.

Table 4. The effects of China–US tariff and non-tariff barrier trade war on countries other than China and the US (unit: percent change %).

	Welfare	GDP	M	NM	Employ	Trade	Export	Import	Welfare	GDP	M	NM	Employ	Trade	Export	Import
Country	Mutual trade war with the same level of 15% trade cost measures								Mutual trade war with the same level of 60% trade cost measures							
China	−0.563	−1.000	−2.934	0.621	−1.953	−4.513	−6.051	−2.654	−1.332	−2.181	−6.385	1.343	−4.298	−9.730	−13.201	−5.533
US	−0.387	0.301	−0.923	0.647	−1.221	−4.751	−2.872	−6.086	−1.104	0.755	−1.875	1.497	−2.610	−10.157	−6.202	−12.965
EU	0.018	−0.001	0.029	−0.015	0.029	0.086	0.066	0.107	0.040	−0.003	0.062	−0.034	0.065	0.219	0.197	0.244
Japan	0.027	0.003	0.069	−0.023	0.066	0.089	0.057	0.118	0.064	−0.009	0.108	−0.055	0.117	0.250	0.211	0.284
Korea	0.066	0.000	0.060	−0.062	0.057	0.008	−0.056	0.080	0.145	−0.046	0.039	−0.136	0.082	0.071	−0.021	0.175
Canada	0.006	0.148	0.429	0.002	0.281	0.229	0.476	−0.005	0.000	0.332	0.940	0.017	0.607	0.610	1.302	−0.043
Australia	0.027	0.005	0.055	−0.023	0.051	−0.009	−0.140	0.126	0.052	−0.047	−0.048	−0.046	−0.001	0.010	−0.229	0.256
New Zealand	0.113	0.197	0.368	−0.056	0.171	0.030	−0.227	0.159	0.110	0.094	0.198	−0.060	0.104	0.069	−0.132	0.169
Singapore	0.049	0.019	0.077	−0.041	0.063	−0.013	−0.082	0.056	0.085	−0.038	−0.001	−0.075	0.039	−0.001	−0.104	0.103
India	0.028	0.024	0.129	−0.022	0.105	0.048	0.021	0.068	0.061	0.004	0.122	−0.048	0.118	0.136	0.124	0.146
Russia	0.033	0.008	0.049	−0.025	0.041	0.028	−0.030	0.120	0.065	−0.022	0.014	−0.050	0.035	0.086	−0.008	0.237
Brazil	0.015	0.017	0.086	−0.012	0.069	0.029	−0.035	0.090	0.027	−0.001	0.050	−0.022	0.051	0.091	0.015	0.164
Mexico	0.031	0.173	0.402	−0.012	0.229	0.249	0.479	0.031	0.049	0.375	0.856	−0.011	0.479	0.659	1.319	0.035
Indonesia	0.060	0.039	0.070	−0.021	0.031	0.058	−0.040	0.145	0.114	−0.011	0.005	−0.043	0.017	0.168	0.033	0.287
Malaysia	0.259	0.110	0.168	−0.169	0.036	−0.016	−0.099	0.061	0.436	0.052	0.126	−0.308	0.047	0.058	0.002	0.110
Philippine	0.109	0.142	0.262	−0.047	0.120	0.051	−0.156	0.159	0.139	0.056	0.136	−0.069	0.080	0.136	−0.037	0.226
Thailand	0.136	0.087	0.171	−0.122	0.079	−0.004	−0.085	0.061	0.218	0.033	0.126	−0.195	0.087	0.055	0.001	0.099
Vietnam	0.514	0.214	0.274	−0.301	0.033	−0.005	−0.114	0.070	0.872	0.148	0.228	−0.540	0.044	0.129	0.134	0.125
Peru	0.118	0.196	0.287	−0.025	0.091	0.063	−0.108	0.149	0.108	0.120	0.179	−0.022	0.059	0.149	0.158	0.144
Brunei	0.099	−0.097	−0.100	−0.080	−0.008	0.033	0.019	0.063	0.227	−0.220	−0.226	−0.177	−0.011	0.054	0.010	0.143
ROW	0.056	−0.015	0.018	−0.031	0.030	0.036	0.001	0.073	0.129	−0.032	0.048	−0.071	0.075	0.108	0.051	0.169
World	−0.134	−0.041	−0.511	0.215	−0.375	−1.230	−1.230	−1.230	−0.370	−0.087	−1.150	0.491	−0.835	−2.606	−2.606	−2.606

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

China–US Tariff Trade War Plus Mexico–US Tariff Trade War

The US president Trump had announced to impose import tariff to the Mexico products, and force Mexico to build and pay for border wall[2] for many times. Therefore we explore the effects of China–US tariff war plus Mexico–US tariff war. For the China–US tariff war, we assume a 45% tariff rate retaliation; and for the Mexico–US tariff war, we assume a sequence of 20% and 35% import tariff wars. The reason for these tariff rate assumptions is that president Trump had ever said to levy a 45% import tariff to Chinese products, and a 35% or 20% import tariffs to Mexico products.

Simulation results show that all three trade war involved countries will be hurt on welfare, GDP, manufacturing employment, and trade. Trade effects are stronger than production and employment effects, and production effects are stronger than welfare effects. Comparatively, tariff wars hurt Mexico the most, hurt China the second most, and hurt the US the least. This results help to explain why the US is willing to initiate trade wars with Mexico and China, but if China and Mexico do not make concessions to the US and choose to retaliate, the US also will be hurt and cannot increase employment as preconceived (see Figure 2).

Specifically when the US have a mutual 45% tariff war with China and a mutual 20% tariff war with Mexico, welfare effects on the US, China and Mexico are separately 0.131%, −0.433%, and −1.645%; GDP effects on the US, China, and Mexico are separately −0.074%, −1.518%, and −3.096%; trade effects on the US, China, and Mexico are separately −5.944%, −9.611%, and −16.758% (see Figure 2).

We compare the tariff war effects on China and the US under situations with and without Mexico–US tariff war. Results show that effects to China are nearly the same whether Mexico engaged in the tariff war or not. But the negative effect to the US will be largely increased when Mexico has tariff war with the US. Specifically, China's welfare losses with or without Mexico engaged in the tariff wars are separately −0.43% and −0.441%; GDP losses are separately −1.518% and −1.514%; trade losses are separately −5.932% and −5.96%. The US's welfare gains with or without Mexico engaged in the tariff wars are separately 0.089% and 0.132%; GDP effects are separately 0.079% and −0.134%; trade effects are separately −6.274% and −11.31% (see Figure 3).

Effects of simultaneously China–US tariff war and Mexico–US tariff war to other countries out of trade war are mostly negative on production and employment, but positive on trade and welfare. But effects to some specific countries are unclear and uncertain.

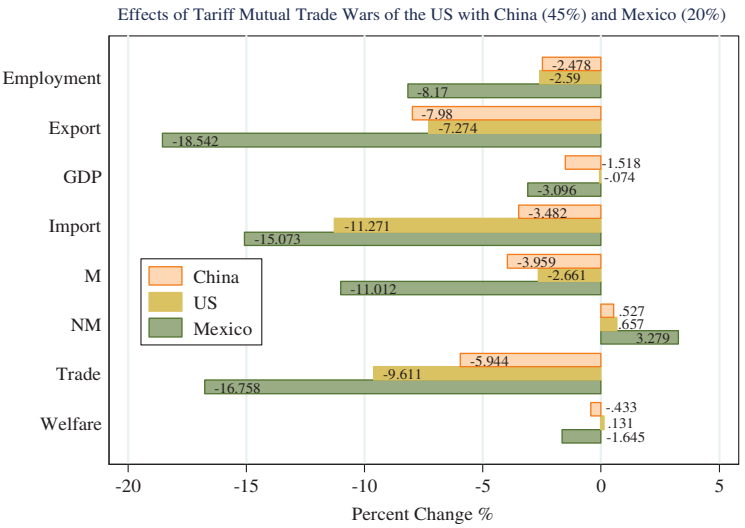

Figure 2. The effects of mutual tariff trade wars by the US to China (45%) and Mexico (20%).
Source: By authors.

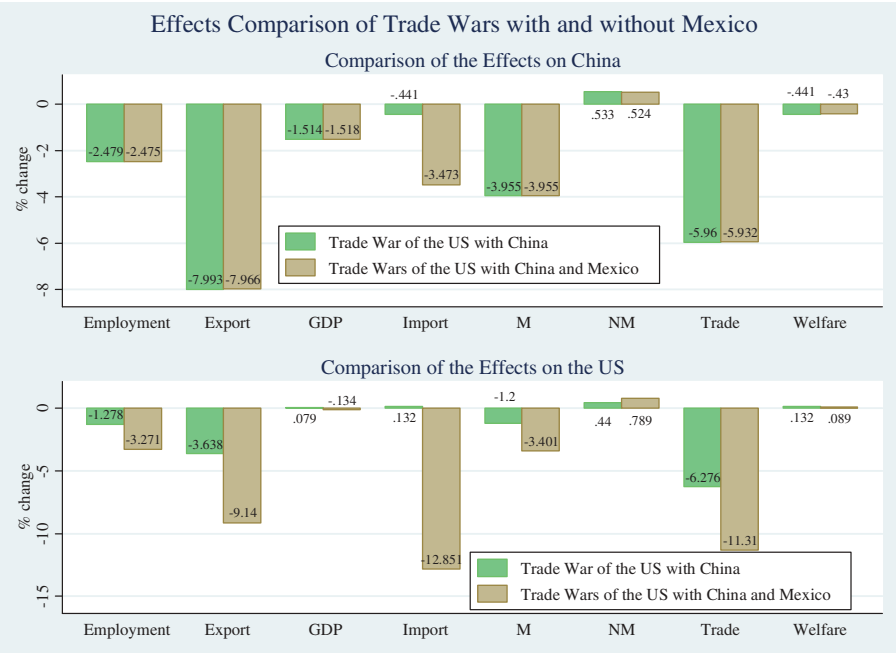

Figure 3. Effects comparison of mutual tariff trade wars with and without Mexico (35% tariff).
Source: By authors.

Effects of the US having tariff wars with both China and Mexico on the world as a whole are negative on welfare, GDP, manufacturing production and employment, total trade, export and import, but positive on non-manufacturing production. When the US has a 45% rate mutual tariff war with China and 35% rate mutual tariff war with Mexico, the world total welfare, GDP and trade will separately decrease by −0.041%, −0.376%, and −2.914% (see Table 5).

Non-Cooperative Nash Bargaining Equilibrium of China–US Trade War

Non-cooperative Nash bargaining equilibrium (NNE) is a trade war point that no countries want to change, so it is the non-cooperative tariff war equilibrium. We explore the effects of tariff war under this Nash equilibrium on China, the US, and other countries.

We firstly explore the effects on China. China's welfare, GDP, manufacturing production, manufacturing employment, trade, export, and import all will be hurt by the China–US trade war. Trade effects are stronger than production and employment effects, production effects are stronger than welfare effects.

Specifically, under the non-cooperative Nash equilibrium, China's welfare will decrease by −0.541%, GDP will decrease by −2.459%, manufacturing employment will decrease by −3.858%, trade will decrease by −7.912%, export will decrease by −12.263%, and import will decrease by −2.653% (see Table 6).

We secondly explore the effects on the US. The US will gain on welfare and GDP, but hurt on manufacturing employment and trade. Trade effects are bigger than production and employment effects, and production effects are stronger than welfare effects. These results also prove that trade war will hurt the employment of the US. Specifically, the US welfare will increase by 0.041%, GDP will increase by 0.611%, employment will decrease by −0.918, and trade will decrease by −8.068% (see Table 6).

We thirdly explore the effects on other countries out of trade war and the world as a whole. Most countries will increase on trade and welfare, but decrease on production and employment. The world will be negatively influenced by trade war on all aspects including welfare, total

Table 5. The effects of China–US plus Mexico–US tariff trade war (unit: percent change %).

	Welfare	GDP	M	NM	Employ	Trade	Export	Import	Welfare	GDP	M	NM	Employ	Trade	Export	Import
Country	Mutual tariff war of the US with China (45% tariff) and Mexico (20% tariff)								Mutual tariff war of the US with China (45% tariff) and Mexico (35% tariff)							
China	−0.433	−1.518	−3.959	0.527	−2.478	−5.944	−7.980	−3.482	−0.430	−1.518	−3.955	0.524	−2.475	−5.932	−7.966	−3.473
US	0.131	−0.074	−2.661	0.657	−2.590	−9.611	−7.274	−11.271	0.089	−0.134	−3.401	0.789	−3.271	−11.310	−9.140	−12.851
EU	0.048	−0.055	−0.084	−0.041	−0.029	0.133	−0.018	0.297	0.052	−0.055	−0.080	−0.044	−0.025	0.154	0.003	0.318
Japan	0.067	−0.102	−0.212	−0.059	−0.110	0.157	−0.010	0.307	0.070	−0.104	−0.211	−0.062	−0.107	0.175	0.012	0.321
Korea	0.117	−0.239	−0.368	−0.103	−0.125	0.056	−0.013	0.134	0.124	−0.242	−0.369	−0.109	−0.123	0.071	0.009	0.141
Canada	0.095	−0.023	0.085	−0.078	0.107	0.448	0.691	0.218	0.128	−0.031	0.115	−0.107	0.146	0.527	0.770	0.297
Australia	0.037	−0.208	−0.523	−0.038	−0.316	0.018	−0.177	0.217	0.040	−0.216	−0.543	−0.040	−0.328	0.026	−0.171	0.229
New Zealand	−0.212	−0.755	−1.323	0.091	−0.572	0.011	0.529	−0.254	−0.223	−0.790	−1.385	0.096	−0.599	0.016	0.572	−0.267
Singapore	0.034	−0.263	−0.480	−0.043	−0.234	0.027	−0.005	0.059	0.035	−0.272	−0.497	−0.044	−0.243	0.032	0.003	0.061
India	0.060	−0.161	−0.418	−0.048	−0.257	0.104	0.046	0.147	0.064	−0.168	−0.432	−0.052	−0.264	0.117	0.062	0.157
Russia	0.037	−0.141	−0.284	−0.027	−0.144	0.046	−0.009	0.135	0.037	−0.145	−0.295	−0.027	−0.149	0.050	−0.004	0.136
Brazil	0.035	−0.138	−0.394	−0.029	−0.257	0.096	−0.033	0.221	0.041	−0.145	−0.406	−0.034	−0.262	0.126	−0.007	0.256
Mexico	−1.645	−3.096	−11.012	3.279	−8.170	−16.758	−18.542	−15.073	−2.824	−4.543	−16.659	5.213	−12.693	−25.472	−28.430	−22.678
Indonesia	0.045	−0.281	−0.415	−0.024	−0.134	0.117	0.070	0.158	0.046	−0.291	−0.431	−0.024	−0.140	0.124	0.085	0.159
Malaysia	−0.004	−0.500	−0.592	−0.056	−0.058	0.158	0.311	0.017	−0.011	−0.518	−0.615	−0.050	−0.062	0.169	0.337	0.015
Philippine	−0.109	−0.596	−0.988	0.020	−0.394	0.092	0.417	−0.081	−0.115	−0.620	−1.029	0.022	−0.411	0.106	0.471	−0.087
Thailand	−0.026	−0.427	−0.610	0.026	−0.173	0.101	0.244	−0.013	−0.027	−0.440	−0.629	0.028	−0.178	0.115	0.275	−0.014
Vietnam	−0.020	−0.739	−0.817	−0.073	−0.043	0.297	0.706	0.013	−0.039	−0.768	−0.851	−0.060	−0.045	0.316	0.755	0.010
Peru	−0.172	−0.707	−1.013	0.037	−0.308	0.114	0.672	−0.167	−0.161	−0.744	−1.065	0.036	−0.324	0.147	0.731	−0.148
Brunei	0.232	−0.230	−0.240	−0.155	−0.015	−0.041	−0.124	0.129	0.237	−0.235	−0.246	−0.155	−0.016	−0.044	−0.129	0.130
ROW	0.113	−0.101	−0.150	−0.077	−0.046	0.050	−0.074	0.181	0.118	−0.101	−0.140	−0.082	−0.037	0.063	−0.058	0.191
World	−0.015	−0.336	−1.393	0.239	−0.951	−2.477	−2.477	−2.477	−0.041	−0.376	−1.617	0.298	−1.162	−2.914	−2.914	−2.914

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

Table 6. The effects of non-cooperative Nash equilibrium China–US trade war (unit: percent change %).

Country	Welfare	GDP	M	NM	Employ	Trade	Export	Import
China	−0.541	−2.459	−6.222	0.696	−3.858	−7.912	−12.263	−2.653
US	0.041	0.611	−0.313	0.872	−0.918	−8.068	−2.244	−12.203
EU	0.059	−0.063	−0.090	−0.050	−0.028	0.175	0.004	0.362
Japan	0.089	−0.133	−0.269	−0.080	−0.136	0.200	−0.036	0.411
Korea	0.143	−0.339	−0.539	−0.130	−0.193	0.004	−0.142	0.167
Canada	−0.013	0.143	0.373	0.024	0.230	0.551	1.199	−0.061
Australia	0.042	−0.281	−0.713	−0.048	−0.433	−0.083	−0.422	0.264
New Zealand	−0.254	−0.915	−1.600	0.105	−0.691	−0.014	0.541	−0.297
Singapore	0.045	−0.337	−0.611	−0.060	−0.296	0.014	−0.052	0.082
India	0.077	−0.191	−0.483	−0.063	−0.293	0.147	0.088	0.190
Russia	0.058	−0.182	−0.355	−0.044	−0.174	0.065	−0.028	0.215
Brazil	0.026	−0.164	−0.498	−0.023	−0.334	0.017	−0.142	0.171
Mexico	0.013	0.138	0.295	0.012	0.156	0.614	1.279	−0.014
Indonesia	0.076	−0.356	−0.520	−0.042	−0.164	0.154	0.045	0.250
Malaysia	0.067	−0.624	−0.725	−0.140	−0.064	0.190	0.346	0.046
Philippine	−0.122	−0.733	−1.209	0.014	−0.479	0.085	0.383	−0.074
Thailand	−0.004	−0.540	−0.759	0.004	−0.207	0.110	0.249	−0.002
Vietnam	0.187	−0.884	−0.960	−0.241	−0.041	0.395	0.890	0.050
Peru	−0.278	−0.825	−1.189	0.057	−0.366	0.065	0.801	−0.306
Brunei	0.326	−0.317	−0.327	−0.246	−0.015	−0.068	−0.199	0.201
ROW	0.143	−0.148	−0.261	−0.092	−0.106	0.015	−0.175	0.217
World	−0.016	−0.264	−1.227	0.259	−0.668	−2.099	−2.099	−2.099

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

production, employment and trade. Specifically, the world welfare will decrease by −0.016%, GDP will decrease by −0.264%, manufacturing production will decrease by −1.227%, and trade will decrease by −2.099% (see Table 6).

We further compare the effects under non-cooperative Nash equilibrium trade war and 45% import tariff trade war. Comparison results show that negative impacts to China are larger under non-cooperative Nash equilibrium, but the negative impacts to the US are smaller under non-cooperative Nash bargaining equilibrium (see Figure 4).

Cooperative Nash Bargaining Equilibrium of China–US Trade War

Cooperative Nash bargaining equilibrium is a steady point after trade war negotiation that both China and the US will not move their import tariffs. We explore the effects of trade war under this cooperative Nash equilibrium and also compare it with non-cooperative Nash equilibrium effects to show both bargaining countries' comparative gains from negotiation, this comparative gains can reveal bargaining power in the trade war negotiation.

Absolute gain values show that the US can gain more on welfare, GDP, manufacturing production, manufacturing employment, total trade and export, but gain less on import. Comparative gain shares also support this result that the US will gain a little more on welfare and total trade; gain much more on GDP, manufacturing production, manufacturing employment and export; but gain less on non-manufacturing production and import. In general, the US can gain more than China from trade war negotiation, so that the US has stronger bargaining power (see Table 7).

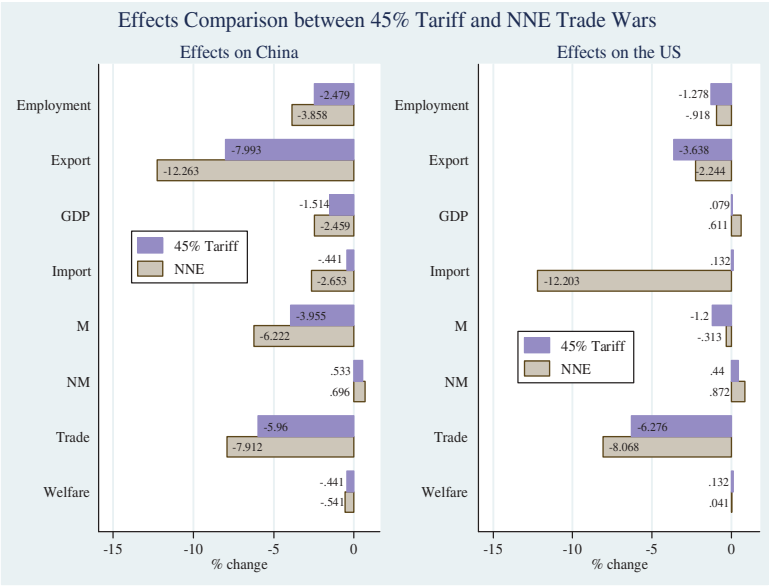

Figure 4. Effects comparison between 45% tariff and NNE trade wars (% change).
Note: NNE denotes Non-cooperative Nash equilibrium.
Source: By authors.

Table 7. Gains of China and the US from Nash cooperation.

Country	Welfare	GDP	M	NM	Employ	Trade	Export	Import
				Absolute gain value				
China	0.983	1.605	0.370	−1.235	0.173	7.192	0.548	6.643
US	0.991	6.605	7.295	−0.690	4.613	8.095	7.355	0.740
				Comparative percent gain share of China and US				
China	49.797	19.549	4.827	64.156	3.615	47.047	6.934	89.977
US	50.203	80.451	95.173	35.844	96.385	52.953	93.066	10.023

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

Compared with benchmark, China will lose on all aspects of welfare, GDP, manufacturing employment, and trade; the US will gain on welfare and GDP, but lose on manufacturing production, employment and trade; and comparatively the US will lose less than China. Most other countries out of trade war will gain on welfare, but lose on trade and production. The world as a whole also will be hurt. Therefore, trade war will mainly hurt war involved countries and the world.

Compared with non-cooperative Nash bargaining equilibrium, nearly all countries will gain. China will gain more than the US on welfare and import, the US will gain more than China on GDP, manufacturing production and employment, total trade and export. Other countries out of trade war gain on welfare, GDP, employment and import, but lose on export (see Table 8).

Sensitivity Analysis to Elasticities

As the elasticities in production functions and consumption functions are all chosen from other literatures, so we perform sensitivity analysis of our simulation results to elasticities in this part. There

Table 8. The effects of cooperative Nash equilibrium China–US trade war (unit: percent change %).

	Welfare	GDP	M	NM	Employ	Trade	Export	Import	Welfare	GDP	M	NM	Employ	Trade	Export	Import
Country	Effects compared with benchmark								Effects compared with non-cooperative Nash equilibrium							
China	−0.553	−2.476	−6.231	0.671	−3.850	−7.738	−12.238	−2.298	0.012	0.018	0.009	−0.024	0.008	0.189	0.028	0.365
US	0.047	0.650	−0.117	0.867	−0.762	−7.860	−1.790	−12.171	0.006	0.039	0.196	−0.005	0.158	0.226	0.464	0.037
EU	0.059	−0.062	−0.089	−0.050	−0.027	0.175	0.003	0.360	0.000	0.000	0.001	0.000	0.001	−0.001	0.000	−0.001
Japan	0.088	−0.133	−0.269	−0.079	−0.136	0.196	−0.043	0.410	0.000	0.000	0.000	0.000	0.000	−0.004	−0.008	−0.001
Korea	0.142	−0.340	−0.542	−0.128	−0.196	−0.005	−0.158	0.165	−0.002	−0.001	−0.004	0.001	−0.002	−0.009	−0.016	−0.002
Canada	−0.017	0.152	0.391	0.028	0.239	0.551	1.210	−0.073	−0.004	0.009	0.018	0.004	0.009	0.000	0.012	−0.012
Australia	0.041	−0.280	−0.712	−0.048	−0.433	−0.095	−0.443	0.263	0.006	0.004	0.001	−0.004	0.002	−0.002	−0.022	−0.001
New Zealand	−0.248	−0.899	−1.572	0.102	−0.678	−0.017	0.515	−0.288	0.006	0.016	0.029	−0.003	0.013	−0.003	−0.027	0.008
Singapore	0.046	−0.334	−0.604	−0.060	−0.292	0.011	−0.059	0.082	0.001	0.003	0.006	0.000	0.004	−0.003	−0.006	0.001
India	0.077	−0.188	−0.474	−0.063	−0.286	0.147	0.087	0.191	0.000	0.003	0.010	0.000	0.007	0.000	−0.001	0.001
Russia	0.059	−0.180	−0.351	−0.045	−0.171	0.063	−0.033	0.218	0.001	0.001	0.004	0.000	0.002	−0.002	−0.004	0.002
Brazil	0.026	−0.163	−0.494	−0.023	−0.331	0.009	−0.154	0.168	−0.002	0.002	0.005	0.002	0.003	−0.001	−0.012	−0.003
Mexico	0.009	0.149	0.313	0.016	0.164	0.617	1.293	−0.022	−0.004	0.010	0.019	0.004	0.008	0.002	0.013	−0.008
Indonesia	0.078	−0.353	−0.514	−0.043	−0.162	0.150	0.035	0.253	0.001	0.004	0.006	0.000	0.002	−0.003	−0.010	0.002
Malaysia	0.073	−0.617	−0.715	−0.145	−0.062	0.184	0.332	0.048	0.006	0.008	0.010	−0.004	0.001	−0.006	−0.014	0.002
Philippine	−0.118	−0.722	−1.189	0.013	−0.470	0.080	0.359	−0.068	0.004	0.012	0.020	−0.002	0.008	−0.005	−0.023	0.006
Thailand	0.000	−0.533	−0.749	0.000	−0.203	0.105	0.237	0.000	0.004	0.006	0.010	−0.003	0.004	−0.005	−0.012	0.002
Vietnam	0.205	−0.868	−0.941	−0.251	−0.039	0.389	0.872	0.053	0.018	0.016	0.020	−0.012	0.002	−0.005	−0.017	0.002
Peru	−0.273	−0.810	−1.166	0.056	−0.359	0.062	0.779	−0.300	0.005	0.016	0.023	−0.001	0.007	−0.003	−0.023	0.005
Brunei	0.326	−0.317	−0.326	−0.247	−0.015	−0.071	−0.204	0.201	0.000	0.002	0.001	0.008	0.002	0.000	−0.005	0.012
ROW	0.142	−0.149	−0.268	−0.091	−0.112	0.008	−0.185	0.214	−0.001	−0.002	−0.008	0.001	−0.006	−0.007	−0.010	−0.003
World	−0.016	−0.257	−1.200	0.256	−0.641	−2.050	−2.050	−2.050	0.000	0.007	0.028	−0.003	0.026	0.050	0.050	0.050

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

are a lot of different scenarios in this simulation, so we choose the 45% import tariff mutual trade war as an example to perform sensitivity analysis. For simplicity, we just give another two different elasticity values of 1.5 and 4.5 to re-calibration and re-simulation the China–US trade war effects.

Comparing these results with different elasticity values, we find that trade war effects are nearly the same, changes are just in number values (see Table 9). Therefore, these results prove that above simulation results are reliable and robustness.

Conclusions

This article builds a 29-region global general equilibrium model with endogenous trade imbalance structure, we incorporate trade cost into the model and divide it into tariff and non-tariff barrier which is feasible to explore the effects of tariff trade wars and non-tariff barrier trade wars. We use real data in 2013 to calibrate parameters and simulate trade war effects. Five different scenarios of trade wars are explored in our simulations, which are import tariff wars, trade cost wars, wars of Mexico involved, non-cooperative Nash bargaining trade wars, and cooperative Nash bargaining trade wars.

Our simulation results find that China will be significantly hurt by China–US trade wars on welfare, gross domestic product (GDP), manufacturing employment and trade. Trade effects are the strongest, production and employment effects are the second strongest, and welfare effects are comparatively weak. The positive increase of non-manufacturing production is the combined effects of full employment assumption in the model and decreased manufacturing production affected by trade war. China's retaliation measures to the US will benefit China but hurt the US. Meanwhile, negative effects of tariff war to China will be positively related with import tariff rates. In conclusion, trade war with the US will hurt China, but cannot hurt China deeply, the negative impacts are affordable.

The US under trade wars will gain on welfare, GDP, and non-manufacturing production, but hurt manufacturing employment and trade (both export and import). If China do not take retaliation measures, the US will gain on manufacturing production, but will lose if China take retaliation measures. The same as China, trade effects are stronger than production and employment effects, and production effects are stronger than welfare effects. As the import tariff rates increase, trade war effects to the US will increase in the beginning but decrease later. It seems that the US government want to improve employment by import tariff measures, our simulation results prove it is impossible to realize this purpose.

Comparing the trade war effects to China and the US, both countries will lose but comparatively China will lose more than the US. So the US is willing to initiate trade war with China to negotiate possible concessions in economics, but China may not want to be involved in trade wars with the US.

Effects on other countries out of the China–US tariff trade war show that most of other countries will gain on welfare and trade, but lose on production (GDP) and manufacturing employment. Especially for the GDP and manufacturing employment effects, nearly all the countries in the world will lose when faced with trade wars between China and the US. The reason may be that trade war between China and the US decreased trade between this two countries, but increased trade with other countries, and the increased trade will improve consumption variety and welfare but decrease production and manufacturing employment. But for a few countries, the GDP and manufacturing effects are positive, it is determined by the specific situation. Sometimes, GDP effects are negative but employment effects are positive, this may reflect that production becomes less efficient (lower productivity) due to less specialization.

Effects of the China–US trade war to the world as a whole are negative, world total welfare, GDP, manufacturing production and employment, export, import, and total trade also decrease except non-manufacturing production. The increased non-manufacturing production is because of full employment assumption and decreased manufacturing production caused by trade war.

If we incorporate non-tariff barrier into the trade war, negative impacts to both China and the US will increase, and comparatively negative effects to China will increase more than to the US. Effects to

Table 9. Sensitivity analysis to elasticities for the 45% tariff mutual trade war between China and the US (unit: percent change %).

	Welfare	GDP	M	NM	Employ	Trade	Export	Import	Welfare	GDP	M	NM	Employ	Trade	Export	Import
Country	Elasticities = 1.5								Elasticities = 4.5							
China	−0.432	−1.474	−3.515	0.221	−2.071	−4.913	−6.885	−2.582	−0.396	−1.419	−5.014	1.693	−3.646	−9.274	−11.044	−7.032
US	0.105	−0.112	−1.011	0.140	−0.900	−5.162	−2.784	−6.809	0.188	0.502	−2.359	1.343	−2.847	−9.961	−7.450	−11.874
EU	0.046	−0.031	−0.058	−0.018	−0.027	0.050	−0.026	0.131	0.019	−0.099	−0.117	−0.091	−0.018	0.324	0.030	0.665
Japan	0.067	−0.066	−0.162	−0.028	−0.096	0.064	−0.026	0.143	0.032	−0.168	−0.234	−0.141	−0.066	0.447	0.132	0.738
Korea	0.112	−0.176	−0.294	−0.053	−0.113	0.015	−0.032	0.068	0.080	−0.306	−0.422	−0.185	−0.112	0.157	0.085	0.235
Canada	0.046	−0.044	−0.093	−0.018	−0.050	0.165	0.284	0.051	−0.022	0.220	0.611	0.015	0.390	0.774	1.662	−0.027
Australia	0.043	−0.143	−0.374	−0.019	−0.231	0.005	−0.094	0.109	0.007	−0.299	−0.741	−0.056	−0.443	−0.051	−0.387	0.268
New Zealand	−0.145	−0.591	−1.009	0.030	−0.421	0.020	0.195	−0.100	−0.303	−0.851	−1.695	0.467	−0.850	−0.332	2.110	−0.829
Singapore	0.045	−0.199	−0.369	−0.025	−0.184	0.009	−0.016	0.034	−0.001	−0.316	−0.587	−0.044	−0.293	0.075	0.095	0.057
India	0.054	−0.114	−0.327	−0.021	−0.213	0.039	0.005	0.064	0.028	−0.210	−0.456	−0.100	−0.247	0.301	0.303	0.300
Russia	0.041	−0.102	−0.212	−0.014	−0.111	0.019	−0.012	0.070	0.013	−0.197	−0.356	−0.068	−0.159	0.178	0.088	0.317
Brazil	0.029	−0.096	−0.296	−0.012	−0.200	0.026	−0.036	0.088	0.005	−0.174	−0.520	−0.022	−0.347	0.041	−0.078	0.152
Mexico	0.056	−0.066	−0.126	−0.018	−0.059	0.172	0.308	0.041	−0.011	0.218	0.526	−0.035	0.307	0.916	1.838	0.099
Indonesia	0.056	−0.210	−0.313	−0.013	−0.103	0.050	0.014	0.083	0.007	−0.353	−0.499	−0.068	−0.146	0.370	0.437	0.319
Malaysia	0.023	−0.410	−0.487	−0.037	−0.048	0.067	0.122	0.013	−0.012	−0.513	−0.584	−0.166	−0.045	0.470	1.054	0.043
Philippine	−0.067	−0.471	−0.770	0.004	−0.301	0.043	0.141	−0.020	−0.144	−0.650	−1.147	0.124	−0.499	0.034	1.525	−0.398
Thailand	−0.014	−0.355	−0.502	0.006	−0.138	0.039	0.089	−0.003	−0.030	−0.436	−0.653	0.119	−0.204	0.282	0.779	−0.053
Vietnam	0.049	−0.598	−0.662	−0.054	−0.035	0.132	0.278	0.012	0.196	−0.524	−0.516	−0.584	0.004	0.643	1.649	0.110
Peru	−0.141	−0.554	−0.783	0.014	−0.231	0.051	0.250	−0.083	−0.301	−0.716	−1.113	0.198	−0.400	−0.232	2.426	−0.819
Brunei	0.260	−0.131	−0.137	−0.086	−0.004	−0.034	−0.079	0.074	0.143	−0.340	−0.321	−0.451	0.016	0.040	−0.111	0.308
ROW	0.133	−0.062	−0.110	−0.038	−0.045	0.016	−0.053	0.089	−0.029	−0.170	−0.225	−0.142	−0.051	0.098	−0.118	0.337
World	0.009	−0.261	−0.823	0.043	−0.439	−1.345	−1.345	−1.345	−0.004	−0.169	−1.306	0.460	−0.929	−2.461	−2.461	−2.461

Note: "M" denotes the production of manufacturing sectors, "NM" denotes the production of non-manufacturing sectors, "Employ" denotes the employment in manufacturing sectors.
Source: Compiled by authors.

other countries out of trade war and the world as a whole all will increase when simultaneously consider tariff and non-tariff trade war.

If Mexico involves in the trade war with the US, results show that all three trade war involved countries will be hurt on welfare, GDP, manufacturing employment and trade. Trade effects are stronger than production and employment effects, and production effects are stronger than welfare effects. Comparatively, tariff wars will hurt Mexico the most, hurt China the second most, and hurt the US the least. Compared with the effects when Mexico is not in the trade war, negative effects on China are nearly the same, but negative effects on the US are largely increased.

Under the non-cooperative Nash bargaining equilibrium, if compared with 45% import tariff mutual trade war, negative impacts to China are larger under non-cooperative Nash equilibrium, but are smaller to the US.

Under the cooperative Nash bargaining equilibrium, if compared with non-cooperative Nash equilibrium, nearly all countries will gain from negotiation. China will gain more than the US on welfare and import, the US will gain more than China on GDP, manufacturing production and employment, total trade and export. Generally, the US can gain more than China from trade war negotiation, which means the US has stronger bargaining power.

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Notes

1. Data are from UN Comtrade database.
2. This border wall effects can be described as increased non-tariff barriers (NTB), and can use NTB change to explore this impact (Bergeijk 2014a, 2014b).

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