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ABSTRACT

This paper uses a numerical global general equilibrium model to simulate the possible effects of US initiated trade protection measures on US manufacturing employment. The simulation results show that US trade protection measures do not increase but will instead reduce manufacturing employment, and US losses will further increase if trade partners take retaliatory measures. The mechanism is that although the substitution effects between domestic and foreign goods have positive impacts, the substitution effects between manufacturing and service sectors and the retaliatory effects both have negative influences, therefore the whole effect is that the US will lose manufacturing employment.

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1. Introduction

Protecting and promoting manufacturing employment is one of the most important objectives of recent and prospective US trade protection measures. The logic often claimed is that reduced imports by tariffs can protect targeted domestic sectors and increase employment. But this is just the direct inference, and does not take into account of other influencing mechanisms. There are three other factors influencing trade protectionism effects on manufacturing employment. Firstly; substitution effects between domestic and foreign goods, which determine how much foreign consumption will be moved to domestic goods after tariff measures. Secondly; substitution effects between manufacturing and service sectors, which determines how much manufacturing consumption will be moved to service sectors. Finally; the retaliation effect. The US tariff measures will undoubtedly encounter retaliation from other countries, which may destroy positive effects of protection. Therefore, it is ambiguous how the US trade protectionism would influence manufacturing employment and so the US hope to increase manufacturing employment through trade protectionism may be just be a wishful dream. Additionally, trade protection measures also have other negative impacts; they prevent a country from reaping the benefits of specialization, disrupt the movement of goods and services, and they lead to a misallocation of resources. Also, consumers and producers often pay higher prices when tariffs are implemented.

There are several other papers which numerically explore the effects of the US trade protectionism but none has manufacturing employment as its objective. Guo et al.

(2018) uses a multi-sector, multi-country general equilibrium (GE) model with intersectional linkages to forecast how exports, imports, output, and real wages would change if Trump's threat of 45% tariffs to China is carried out. Ciuriak and Xiao (2018) introduce the GTAP general equilibrium model to quantify the impacts of the US section 232 steel and aluminium tariffs to Canada. Bouet and Laborde (2017) use a static multi-country and multi-sector Armington trade model to evaluate potential trade wars between the US and emerging countries. But little research has been done on the trade protection effects on manufacturing employment. Li et al. (2018) explores the economic impacts of the possible China-US trade wars with a numerical GE simulation methodology, and finds a negative influence to the US manufacturing employment. Petersen et al. (2017) uses a numerical GE model to simulate the effects of the US withdrawal from NAFTA, introducing a border adjustment tax and trade protection measures to the rest of the world. Results show that tariff measures from the US will hurt manufacturing employment. But this research are not focused on the manufacturing employment effects.

Additionally, there is a series of literature exploring reasons of the US manufacturing employment decline. One stream of papers evaluates whether Chinese exports can account for the decline of US manufacturing employment, including David et al. (2013), Feenstra et al. (2017), Amiti et al (2017), etc. Another stream of papers exploring relations of technological change and the falling US manufacturing employment, including Harrison and McMillan (2011), Ebenstein et al. (2014), Harrison and Fontagne (2017), and etc. These papers relate to the reasons for the US trade protection measures, but do not look at the influence of trade protection measures on manufacturing employment.

Based on these backgrounds, we build a multi-country and multi-sector GE model with endogenous trade imbalance to numerically simulate the manufacturing employment effects of the US trade wars with other countries, including China, the EU, Canada and Mexico. The purpose of the research is to check whether the US trade protection measures can increase manufacturing employment. Our simulation results will have implications for US trade protectionism measures, and also improve understanding of theoretical relations between trade protectionism and manufacturing employment.

This paper is organized as follows: Section 2 introduces the GE model, data and parameter calibration. Section 3 reports the simulation results for different scenarios. Section 4 gives sensitivity and robustness analysis results. Section 5 draws conclusions and policy implications.

2. GE Model, Data and Parameters Calibration

2.1 Model Structure

We build a global general equilibrium model and add a monetary structure using inside money following Whalley et al. (2011) to endogenously determine the trade imbalance. In our global general equilibrium model with monetary structure, we allow inter-commodity trade to co-exist within the period along with trade in debt in the form of inside money. We use a single period model where either claim on future consumption (money holding) or future consumption liabilities (money issuance) enter the utility function as incremental future consumption from current period savings. This is the formulation of inside money used by Patinkin (1971) and Archibald and Lipsey (1960).

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

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

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 is a nested CES utility function. We use the Armington assumption of product heterogeneity across countries, and assume claims on future consumption enter preferences and are traded between countries. Each country can thus either issue or buy claims on future consumption using current period income. The first utility level has N consumption goods and one inside money.

For simplicity, we consume a two goods situation, which are manufacturing goods and non-manufacturing goods, so the first level utility function is

$$U_i(X_i^T, X_i^{NT}, Y_i) = [\alpha_{i1}^{\frac{1}{\sigma_i}}(X_i^T)^{\frac{\sigma_i - 1}{\sigma_i}} + \alpha_{i2}^{\frac{1}{\sigma_i}}(X_i^{NT})^{\frac{\sigma_i - 1}{\sigma_i}} + \alpha_{i3}^{\frac{1}{\sigma_i}}(Y_i)^{\frac{\sigma_i - 1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i - 1}}, \quad i = country \tag{2}$$

Where X_i^{NT} denotes the consumption of non- manufacturing goods in the country i, X_i^T denotes the consumption of composite Armington manufacturing goods in the country i, and Y_i denotes the inside money for the country i. Additionally α_{i1}, α_{i2} and α_{i3} are share parameters and σ_i is the top level elasticity of substitution in consumption.

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

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

Where x_{ij}^T is the consumption of manufacturing 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 $j's$ manufacturing goods consumed in the country i. $\sigma_i^{'}$ is the elasticity of substitution in level two preferences in the country i.

We assume a representative consumer in the country i with income as I_i. The budget constraint for this consumer's consumption is

$$P_i^T X_i^T + pc_i^{NT} X_i^{NT} + pc_i^Y Y_i = I_i \tag{4}$$

Here, Y_i represents both inside money (debt) held by country i, and also country $i's$ trade imbalance. $Y_i > 0$ implies a trade surplus (or positive claims on future consumption); $Y_i < 0$ implies a trade deficit or future consumption liabilities (effectively money issuance), and $Y_i = 0$ implies trade balance.

For trade deficit countries, the utility will decrease in inside money since they are the issuer. In order to capture this given that $Y_i < 0$ for these countries, we use an upper bound Y^0 in the utility function in a term $[Y^0 + Y_i]$ following Whalley et al. (2011) and assume that Y^0 is large enough to ensure that $Y^0 + Y_i > 0$. We use the transformation $y_i = Y^0 + Y_i$ to solve the optimization problem and yields

$$X_i^T = \frac{\alpha_{i1} I_i^*}{(P_i^T)^{\sigma}[\alpha_{i1}(P_i^T)^{1-\sigma} + \alpha_{i2}(pc_i^{NT})^{1-\sigma} + \alpha_{i3}(pc_i^Y)^{1-\sigma}]} \tag{5}$$

$$X_i^{NT} = \frac{\alpha_{i2} I_i^*}{(pc_i^{NT})^{\sigma}[\alpha_{i1}(P_i^T)^{1-\sigma} + \alpha_{i2}(pc_i^{NT})^{1-\sigma} + \alpha_{i3}(pc_i^Y)^{1-\sigma}]} \tag{6}$$

$$y_i = \frac{\alpha_{i3} I_i^*}{(pc_i^Y)^{\sigma}[\alpha_{i1}(P_i^T)^{1-\sigma} + \alpha_{i2}(pc_i^{NT})^{1-\sigma} + \alpha_{i3}(pc_i^Y)^{1-\sigma}]} \tag{7}$$

where P_i^T, pc_i^{NT} and pc_i^Y are respectively consumption prices of composite manufacturing goods, non- manufacturing goods and inside money in the country i.

For the composite of manufacturing goods, they enter the second level preferences and come from different countries, and the country specific demands are

$$x_{ij}^T = \frac{\beta_{ij}(X_i^T P_i^T)}{(pc_{ij}^T)^{\sigma_i'}[\sum_j \beta_{ij}(pc_{ij}^T)^{(1-\sigma_i')}]} \tag{8}$$

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

$$P_i^T = [\sum_{j=1}^{5} \beta_{ij}(pc_{ij}^T)^{(1-\sigma_i')}]^{\frac{1}{1-\sigma_i'}} \tag{9}$$

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

$$Q_i^T = \sum_j x_{ji}^T \tag{10}$$

$$\sum_l F_i^l = \overline{F_i} \tag{11}$$

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

$$p_i^l Q_i^l = w_i^K K_i^l + w_i^L L_i^l \quad l = I, T \tag{12}$$

Where p_i^l is the producer price of goods l in country i. For global trade (or money) clearance, we also have

$$\sum_i Y_i = 0 \tag{13}$$

We introduce tariff for trade between countries, and denote the import tariff in the country i as t_i. This yields the following relation of consumption prices and production prices in the country i for country $j's$ exports.

$$pc_{ij}^{T} = (1+t_i)p_j^{T} \tag{14}$$

Import tariffs will generate revenues R_i, which are given by

$$R_i = \sum_{j,i\neq j} p_j^{T} x_{ij}^{T} t_i \tag{15}$$

The representative consumer's income in country i is thus given by

$$w_i^{K}\overline{K_i} + w_i^{L}\overline{L_i} + R_i = I_i \tag{16}$$

Using the general equilibrium model above, we can calibrate it to a base case data set and then simulate the potential effects.

2.2 Data and Parameters Calibration

We use 2016 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; 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 labour (L). We include only two goods in our model structures, which are manufacturing goods and non- manufacturing goods.

All countries' factor input and production data are calculated from WDI of World Bank database. We use agriculture and service share of GDP data and GDP data to yield production data of manufacturing goods and non-manufacturing goods and use capital/GDP ratio to yield capital and labour input in production. We set the upper bound (Y^0) in our monetary structure to equal 1000 in all countries. We use world values minus all individual countries to generate ROW values. For the two goods, we assume secondary industry (manufacturing) reflects manufacturing goods, and primary and tertiary industries (agriculture, extractive industries, and services) yield non-manufacturing goods. For the two factor inputs, we use total labour income (wage) to denote labour values for inputs by sector. 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. We obtain each country's import tariff data from the WTO Statistics Database. For ROW, we cannot obtain its import tariff directly, and so we use world average tariff rate to denote its value.

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 two, so we set all these elasticities in our model to two (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. 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 the different scenarios we set in the paper.

3. Simulation Results

The US had already initiated tariff wars with China, the EU, Canada and Mexico and we explore the effects of different country groups one by one to check whether the US can gain from tariff protection on manufacturing employment. For each country group scenario, we analyse both the US unilateral tariff wars and bilateral tariff wars (tariff initiation and retaliation). For each type of tariff wars, we set three levels of tariffs which are 30%, 45% and 60%. For the simulation results, we mainly pay attention to the effects on the US, and also some tariff wars related countries of Canada, China, the EU and Mexico. Additionally, employment effects on the whole world will be included in our analysis either.

3.1 Manufacturing Employment Effects of the US Tariff Wars with China

The US-China tariff war simulation results show that the US will lose on manufacturing employment in both unilateral and bilateral tariff wars. As the tariff level increases, the US lose more on manufacturing employment. Meanwhile, negative effects to the US are larger in bilateral tariff wars than in unilateral tariff wars. Therefore, although import tariffs protected the US domestic manufacturing sectors and may switch demands from foreign to domestic, the increased consumption price also switched demand and production from manufacturing sectors to service sectors. Then the whole effect is that the US manufacturing production and employment decrease. Specifically, under the US unilateral tariff wars, US manufacturing employment with the tariff rates of 30%, 45% and 60% are separately -1.329%, -1.786% and -2.152%.

Under bilateral tariff wars, US manufacturing employments with the tariff rates of 30%, 45% and 60% are separately -2.639%, -3.326% and -3.809% (see Table 1).

Table 1: Manufacturing Employment Effects of the US Tariff Wars with China (% Change)

Country	Unilateral 30% Tariff	Unilateral 45% Tariff	Unilateral 60% Tariff	Bilateral 30% Tariff	Bilateral 45% Tariff	Bilateral 60% Tariff
Canada	1.560	1.985	2.280	1.944	2.217	2.357
China	**-0.099**	**-0.130**	**-0.152**	**-0.547**	**-0.701**	**-0.816**
EU	0.211	0.279	0.332	0.298	0.363	0.404
Mexico	1.224	1.544	1.760	1.476	1.656	1.738
US	**-1.329**	**-1.786**	**-2.152**	**-2.639**	**-3.326**	**-3.809**
World	-0.235	-0.325	-0.399	-0.521	-0.668	-0.773

Source: by authors.

China as a country involved in a tariff war also suffers on manufacturing employment because China has been hurt by the US tariff protection measures. With the increase of the import tariff rate, the negative impact on China's manufacturing employment is increasing. Compared with negative impacts to the US, China loses less. Meanwhile, negative effects to China under bilateral tariff wars are stronger than under unilateral tariff wars. Specifically, manufacturing employment effects under unilateral tariff wars at tariff rates of 30%, 45% and 60% are separately -0.099%, -0.13% and -0.152%; effects under bilateral tariff wars are separately -0.547%, -0.701% and -0.816% (see Table 1).

Manufacturing employment effects on other countries outside of the tariff wars are all positive. As the import tariff rates increase, the positive effects increase. Additionally, positive effects to other countries are larger under bilateral tariff wars. World manufacturing employment will decrease under the US-China tariff wars, negative effects are larger as tariff war rates increase and larger under bilateral tariff wars. Specifically, under unilateral trade wars with tariff rates of 30%, 45% and 60%, world manufacturing employment will separately decrease 0.235%, 0.325% and 0.399%; and under bilateral trade wars with tariff rates of 30%, 45% and 60%, world manufacturing employment will separately decrease 0.521%, 0.668% and 0.773% (see Table 1).

3.2 Manufacturing Employment Effects of the US Tariff Wars with EU

Under the US and EU tariff trade wars, all involved countries will lose, meaning that the US cannot gain employment from trade protection measures. Comparatively, the US will lose more manufacturing employment than the EU. The larger the tariff rates both regions levy, the stronger the negative effects of manufacturing employment to both. Negative effects under bilateral trade wars are more severe under unilateral trade wars. Specifically, the US will receive negative effects of -1.338, -1.778% and -2.122% under unilateral tariff wars of 30%, 45% and 60% rates, and receive negative effects of -3.649%, -3.283% and -5.779%. The manufacturing employment effects to the EU under unilateral 30%, 45% and 60% rates of tariff wars are separately -0.762%, -1.024% and -1.233%, and under the bilateral tariff wars these effects are separately -1.081%, -1.561% and -1.726% (see Table 2).

Table 2: Manufacturing Employment Effects of the US Tariff Wars with EU (% Change)

Country	Unilateral 30% Tariff	Unilateral 45% Tariff	Unilateral 60% Tariff	Bilateral 30% Tariff	Bilateral 45% Tariff	Bilateral 60% Tariff
Canada	1.074	1.439	1.729	2.093	1.652	3.238
China	0.012	0.016	0.020	-0.089	-0.497	-0.137
EU	**-0.762**	**-1.024**	**-1.233**	**-1.081**	**-1.561**	**-1.726**
Mexico	0.976	1.306	1.568	1.691	1.521	2.600
US	**-1.338**	**-1.778**	**-2.122**	**-3.649**	**-3.283**	**-5.779**
World	-0.352	-0.470	-0.563	-0.909	-0.874	-1.458

Source: by authors.

Manufacturing employment effects to uninvolved countries are mostly positive, except China under the US-EU bilateral tariff wars. China's received negative effects under bilateral tariff wars is determined by trade relations between countries, because both the US and EU are China's big trade partners. The US-EU tariff wars have negative impacts on the world, and the effects are larger under bilateral trade wars. As the tariff rates increase, the world manufacturing employment negative effects increase.

3.3 Manufacturing Employment Effects of the US Tariff Wars with Canada

If the US and Canada have tariff wars, both countries will lose on manufacturing employment, and comparatively Canada loses much more than the US. As tariff rates increase, the negative employment effects on both countries increase. Simulation results prove that the US cannot gain manufacturing employment when having trade wars with Canada. Specifically, under unilateral tariff wars with 30%, 45% and 60% rates, the US manufacturing employment will lose -1.617%, -2.128% and -2.521%, and Canada will lose -14.009%, -18.932% and -22.898%. Meanwhile, under bilateral tariff wars with 30%, 45% and 60% rates, the US manufacturing employment will separately lose -3.035%, -3.575% and -4.203%, and Canada will separately lose -23.078%, -23.919% and -28.435% (see Table 3).

Manufacturing employment effects to other countries outside of trade wars are mostly positive except China under unilateral tariff wars and some lower tariff rate bilateral tariff wars. The world as a whole will lose on manufacturing employment under both unilateral and bilateral US-Canada tariff wars. Specifically, under unilateral tariff wars with rates of 30%, 45% and 60%, the world manufacturing employment will decrease separately -0.479%, -0.642% and -0.771%; and under bilateral tariff wars with rates of 30%, 45% and 60%, the world will decrease separately -0.908%, -1.113% and -1.315% (see Table 3).

Table 3: Manufacturing Employment Effects of the US Tariff Wars with Canada (% Change)

Country	Unilateral 30% Tariff	Unilateral 45% Tariff	Unilateral 60% Tariff	Bilateral 30% Tariff	Bilateral 45% Tariff	Bilateral 60% Tariff
Canada	**-14.009**	**-18.932**	**-22.898**	**-23.078**	**-23.919**	**-28.435**
China	-0.041	-0.054	-0.063	-0.462	0.012	0.013
EU	0.047	0.063	0.076	0.043	0.024	0.029
Mexico	0.706	0.933	1.109	0.786	0.184	0.221
US	**-1.617**	**-2.128**	**-2.521**	**-3.035**	**-3.575**	**-4.203**
World	-0.479	-0.642	-0.771	-0.908	-1.113	-1.315

Source: by authors.

3.4 Manufacturing Employment Effects of the US Tariff Wars with Mexico

Under the US-Mexico trade wars, both countries' manufacturing employment will decrease and comparatively Mexico's relative decrease is much more than the US. As import tariffs increase, both countries' loss on manufacturing employment increases. Meanwhile, both countries' manufacturing employment will decrease more under bilateral tariff wars than under unilateral tariff wars. Specifically, under unilateral tariff wars with tariff rates of 30%, 45% and 60%, the US manufacturing employment will decrease separately by -1.254%, -1.658% and -1.971%; and Mexico will decrease separately by -11.394%, -15.474% and -18.79%. Under bilateral tariff wars with tariff rates of 30%, 45% and 60%, the US manufacturing employment will decrease separately by -2.099%, -2.75% and -3.245%; and Mexico will decrease separately by -13.85%, -18.514% and -22.191% (see Table 4).

Other countries outside of the US-Mexico tariff wars can mostly gain on manufacturing employment, with the exception of China. China's manufacturing employment will decrease under trade wars between the US and Mexico. The whole world's manufacturing employment will decrease under both unilateral and bilateral US-Mexico tariff wars. Specifically, the world's manufacturing employment will separately decrease by -0.353%, -0.475% and -0.573% under unilateral tariff wars with tariff rates of 30%, 45% and 60%; and decrease by -0.617%, -0.815% and -0.968% under bilateral tariff wars with tariff rates of 30%, 45% and 60% (see Table 4).

Table 4: Manufacturing Employment Effects of the US Tariff Wars with Mexico (% Change)

Country	Unilateral 30% Tariff	Unilateral 45% Tariff	Unilateral 60% Tariff	Bilateral 30% Tariff	Bilateral 45% Tariff	Bilateral 60% Tariff
Canada	0.851	1.13	1.348	0.239	0.324	0.392
China	-0.043	-0.056	-0.067	-0.001	-0.002	-0.003
EU	0.039	0.052	0.062	0.017	0.022	0.027
Mexico	**-11.394**	**-15.474**	**-18.79**	**-13.85**	**-18.514**	**-22.191**
US	**-1.254**	**-1.658**	**-1.971**	**-2.099**	**-2.75**	**-3.245**
World	-0.353	-0.475	-0.573	-0.617	-0.815	-0.968

Source: by authors.

4. Sensitivity and Robustness Analysis

We perform sensitivity analysis to preference elasticities, and robustness check with trade cost wars and different model structure simulations.

4.1 Sensitivity Analysis to Preference Elasticities

Preference elasticities in our paper are randomly determined to equal two according to some literature. We need to have a sensitivity analysis to preference elasticities. We change preference elasticities to separately equal 1.5, 3.0 and 4.5 to check the sensitivity of simulation results. As we have two different preference elasticities in our utility function, which are elasticities of manufacturing and non-manufacturing goods, and elasticities of domestic and foreign goods. Therefore, we perform sensitivity analysis to both elasticities separately and simultaneously, totalling three different situations.

For simplicity, we only report sensitivity analysis results to the US-China bilateral tariff war with 45% rate. Sensitivity analysis results are listed in Table 5. Columns 2-4 are sensitivity analysis to elasticity of manufacturing and non-manufacturing goods. Columns 5-7 are sensitivity analysis to elasticities of domestic and foreign goods. Columns 8-10 are sensitivity analysis to simultaneous change of both elasticities. Results show that negative effects to both China and the US on manufacturing employments increase as elasticity of manufacturing and non-manufacturing goods increase, decrease as elasticity of domestic and foreign goods increase, and increase as whole preference elasticities increase. Sensitivity analysis show that an elasticity change only influences effect intensity and does not influence effect direction.

Table 5: Sensitivity Analysis of US-China Bilateral Tariff War to Elasticities (% Change)

Country	E1=1.5	E1=3.0	E1=4.5	E2=1.5	E2=3.0	E2=4.5	E3=1.5	E3=3.0	E3=4.5
Canada	2.325	1.663	0.332	2.056	2.349	2.538	2.278	2.083	1.950
China	**-0.447**	**-1.151**	**-1.757**	**-0.798**	**-0.542**	**-0.356**	**-0.535**	**-0.952**	**-1.201**
EU	0.296	0.363	0.197	0.339	0.324	0.234	0.315	0.419	0.456
Mexico	1.784	1.085	-0.277	1.538	1.736	1.905	1.773	1.438	1.237
US	**-2.183**	**-5.246**	**-7.604**	**-3.906**	**-2.111**	**-0.740**	**-2.838**	**-4.058**	**-4.690**
World	-0.417	-1.156	-1.854	-0.809	-0.427	-0.130	-0.537	-0.863	-1.032

Note: (1) E1 denotes the preference elasticity of manufacturing and non-manufacturing goods, E2 denotes the preference elasticity of domestic and foreign goods, E3 denotes the preference elasticity of both different goods and goods from different countries.

Source: by authors.

4.2 Robustness Check with Both Tariff and Non-tariff Wars

Above analysis only analysed the manufacturing employment effects of trade wars, and we further explore the effects of trade cost (both tariff and non-tariff) wars to check the robustness of our simulation results.

In order to analyse the trade cost war effects, we introduce trade costs into the model. 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, import tariff and non-tariff trade costs. 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 feature through the use of non-tradable goods equal in value terms to the cost of the barrier. We calculate trade costs following the approaches in Wong (2012) and Novy (2013). 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 captures all barriers.

Using the GE model with trade cost, we simulate the manufacturing employment effects of trade cost wars. For simplicity, we only report the results of the US-China trade cost wars. Simulation results show that negative effects of manufacturing employment to both the US and China are stronger under trade cost wars and that comparatively the US loss is larger than Chinas. All other results are the same as under tariff wars. Specifically, negative effects of manufacturing employment to the US under unilateral trade cost wars with import rates of 30%, 45% and 60% are -2.519%, -3.106% and -3.493%; and under bilateral trade cost wars are -4.237%, -4.846% and -5.187%. Negative effects of manufacturing employment to China under unilateral trade cost wars with import rates of 30%, 45% and 60% are -0.154%, -0.186% and -0.207%; and under bilateral trade cost wars are -1.014%, -1.195% and -1.303% (see Table 6). Robustness checks with trade cost wars prove that the above simulation results are reliable.

Table 6: Manufacturing Employment Effects of the US Trade Cost Wars with China (% Change)

Country	Unilateral 30% TC	Unilateral 45% TC	Unilateral 60% TC	Bilateral 30% TC	Bilateral 45% TC	Bilateral 60% TC
Canada	2.229	2.598	2.815	2.306	2.425	2.465
China	**-0.154**	**-0.186**	**-0.207**	**-1.014**	**-1.195**	**-1.303**
EU	0.328	0.403	0.454	0.394	0.441	0.466
Mexico	1.721	1.982	2.128	1.708	1.763	1.769
US	**-2.519**	**-3.106**	**-3.493**	**-4.237**	**-4.846**	**-5.187**
World	-0.464	-0.584	-0.664	-0.867	-1.003	-1.079

Note: TC denotes trade cost (both tariff and non-tariff) wars.
Source: by authors.

4.3 Robustness Check with Different Model Structures

We use a different model structure to check the robustness of our simulation results.

We introduce another kind of endogenous trade imbalance model structure to do our simulation. We follow Whalley and Wang (2010) to build the model structure. 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. If the exchange rate is fixed, then the relative domestic money stock needs to accommodate it 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, I_i is the total income of country i, $\overline{M}_i$ is the money supply in 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 general equilibrium model yielding an endogenous monetary trade imbalance GE model. Using this new model, we simulate our analysis. For simplicity, we only report the results of the US-China tariff wars. Simulation results reveal that manufacturing employments of both the US and China will decrease, and comparatively the US decrease more than China. Simulation results with this different model structure are close to above main results, which proves the robustness of our simulation results (see Table 7).

Table 7: Employment Effects of US-China Tariff Wars with A Different Model (% Change)

Country	Unilateral 30% Tariff	Unilateral 45% Tariff	Unilateral 60% Tariff	Bilateral 30% Tariff	Bilateral 45% Tariff	Bilateral 60% Tariff
Canada	0.072	0.111	0.149	0.028	0.053	0.080
China	**-0.144**	**-0.210**	**-0.270**	**-0.957**	**-1.278**	**-1.533**
EU	-0.025	-0.031	-0.033	-0.027	-0.032	-0.034
Mexico	0.049	0.076	0.103	0.006	0.020	0.037
US	**-1.810**	**-2.407**	**-2.875**	**-1.861**	**-2.479**	**-2.965**
World	-0.279	-0.372	-0.444	-0.416	-0.550	-0.655

Source: by authors.

5. Conclusions and Remarks

This paper uses a numerical 29-country global GE model with inside money to endogenously determine trade imbalance, and simulate manufacturing employment effects of the US initiated trade protection measures including both unilateral and bilateral tariff measures. We set three levels of tariff rates to separately equal 30%, 45% and 60%, and explore the US tariff wars with China, the EU, Canada and Mexico.

Simulation results suggest that the US may not gain manufacturing employment by taking trade protection measures against China, the EU, Canada and Mexico. Instead, US manufacturing employment may decrease when taking trade protection measures against its trade partner countries. As the US tariff rate increases, the manufacturing employment losses of both countries in the trade war increase. The US's manufacturing employment losses are larger than partner countries in the US-China trade war and the US-EU trade war, and are smaller than partner countries in the US-Canada trade war and the US-Mexico trade war. Sensitivity analysis finds that both trade war involved countries' manufacturing employment loss increases as the preference elasticity of manufacturing and non-manufacturing goods increases, decreases as the preference elasticity of domestic and foreign goods increases, and increases as the whole preference elasticity increases.

Our research results suggest that the US manufacturing employment will decrease if the US take trade protection measures to some trade partner countries including China, the EU, Canada and Mexico. US manufacturing employment will further decrease if trade partner countries take retaliatory measures. This suggests that the US wanting to save manufacturing employment through trade protection measures may be unachievable.

References

Amiti, M., M. Dai, R.C. Feenstra and J. Romalis. 2017. "How Did China's WTO Entry Affect US Prices". NBER Working Paper No.23487.

Archibald, G.C. and R.G. Lipsey. 1960. "Monetary and Value theory: Further Comment". The Review of Economic Studies, 28(1): 50-56.

Bouet A. and D. Laborde. 2017. "US Trade Wars with Emerging Countries in the 21st Century: Make America and Its Partners Lose Again". IFPRI Discussion Paper 01669.

Ciuriak, D. and J. Xiao. 2018. "Quantifying the Impacts of the US Section 232 Steel and Aluminum Tariffs". C.D. Howe Institute Working Paper, 06-12-2018.

David, H., D. Dorn and G.H. Hanson. 2013. "The China Syndrome: Local Labor Market Effects of Import Competition in the United States". American Economic Review, 103(6): 2121-2168.

Ebenstein, A., A. Harrison, M. McMillan and S. Phillips. 2014. "Estimating the Impact of Trade and Offshoring on American Workers Using the Current Population Surveys". Review of Economics and Statistics, 96(4): 581-595.

Feenstra, R.C., H. Ma and Y. Xu. 2017. "US Exports and Employment". NBER Working Paper No.24056.

Guo, M., L. Lu, L. Sheng and M. Yu. 2018. "The Day After Tomorrow: Evaluating the Burden of Trump's Trade War". Asian Economic Papers, 17(1): 101-120.

Harrison, A. and L. Fontagne. 2017. "The Factory-Free Economy, Outsourcing, Servitization, and the Future of Industry". London, UK: Oxford University Press.

Harrison, A. and M. McMillan. 2011. "Offshoring Jobs? Multinationals and US Manufacturing Employment". Review of Economics and Statistics, 93(3): 857-875.

Li, C., C. He and C. Lin. 2018. "Economic Impacts of the Possible China-US Trade War". Emerging Markets Finance and Trade, 54(7): 1557-1577.

Novy, D. 2013. "Gravity Redux: Measuring International Trade Costs with Panel Data". Economic Inquiry, 51(1): 101-121.

Patinkin, D. 1971. "Inside Money, Monopoly Bank Profits, and the Real-Balance Effect: Comment". Journal of Money, Credit and Bank, 3: 271-275.

Petersen, T., U. Schoof, E. Yalcin, G. Felbermayr and M. Steininger. 2017. "Global Impact of a Protectionist U.S. Trade Policy". GED Focus Paper, September-2017.

Whalley, J and L. Wang. 2010. "The Impact of Renminbi Appreciation on Trade Flows and Reserve Accumulation on a Monetary Trade Model". Economic Modelling, 28: 614-621.

Whalley, J., J. Yu and S. Zhang. 2011. "Trade Retaliation in a Monetary-Trade Model". Global Economy Journal, 11(1): 1-28.

Wong, A. 2012. "Measuring Trade Barriers: An Application to China's Domestic Trade". Job Market Paper, University of Chicago, January 2012.