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The 2008 Financial Crisis and the Lack of Retaliatory Trade Intervention*

Abstract: The 2008 financial crisis did not precipitate global retaliatory trade intervention, in seeming contrast to the Great Depression in 1930s. This paper discusses the influence of model structure in optimal tariff (OT) calculations in explaining this puzzle. We emphasize how earlier literature reports high optimal tariffs in numerical calculation (of a hundred of percent) but only uses simple trade models. We use numerical general equilibrium calibration and simulation methodology to calculate optimal tariffs both with and without retaliation in a series of observationally equivalent models, and explore the influence of model structures on optimal tariff levels. We gradually add more realistic features into basic general equilibrium model, and show sharply decline optimal tariffs, which suggests that trade retaliation incentives effectively disappear with the deepening of globalization in 2008 compared to 1930.

Keywords: Optimal Tariffs, General Equilibrium, Model Structure, Trade Liberalization

JEL Classification: F11, C63, F13

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1. Introduction

To trade economists it remains as a seeming puzzle that the global economy can have passed through the 2008 financial crisis without an outbreak of retaliatory trade intervention in the form of trade barriers being constructed to protect national markets and employment. While it is the case that cooperative arrangements were in place to present such occurrence, such as bound tariffs in the WTO and WTO codes in such areas as government procurement and subsidies, the parallels drawn at the time to the 1930's including the retaliatory beggar this neighbor trade policies suggested that the pressures for intervention in the face of such a sharp trade shock would be overwhelming.

In this paper we offer a possible explanation for this seeming non-occurrence of trade retaliation. First, we point out that retaliatory trade measures in the 1930's have over the years been somewhat overstated in terms of their severity. The most dramatic step occurred with the US Smoot-Hawley tariff in the spring of 1929 which was well before the large trade shock which followed. This was then followed by a single round of localized and product specific tariff retaliation in a number of European countries, which, over time, triggered no further tariff response. Rather, what followed at the height of the trade compression was a series of competitive devaluations designed to protect employment.

Secondly, and as the heart of the paper, we suggest the prevalent view of the imminence of an outbreak of trade retaliation in the 2008/2009 was in part based on a literature that only analyzed trade retaliation in a sharply restricted set of models which if modified to add more realism produce progressively less and less retaliation. In essence, trade models with progressive features of realism added produce shrinking optimal tariffs and so today's globalized world compared to the 1930s produce no retaliation.

We begin by reviewing literature both on the 1930's and optimal tariffs, long associated with the classic paper by Johnson (1953-1954). We then turn to the literature from the 1970's and later (up to today) which uses general equilibrium models to compute optimal tariffs. These models, which all use the Armington product heterogeneity by country assumption produce optimal tariffs in the global economy which after retaliation are often in the range of a hundred percent.

We then turn to numerical simulation and first generate a data set of country trade, production and consumption for 2013 which incorporates the US, the EU, China, Japan, India, Brazil and ROW (rest of the world). This data set is used to calibrate a series of nested but progressively more complex models which are all observation equivalent in that they calibrate to the same data. We produce supporting parameterizations for each model in the nested structure. For each model in the nest we are able to compute optimal tariffs and in the process calibrate to literature based import demand elasticities. Throughout the nesting hierarchy all models are calibrated to the same data and elasticities. Our calculations of optimal tariffs with those models show optimal tariffs fall from the hundreds of percent to single digits by using more complex models and hence to trade barriers of little consequence. This suggests the explanation for the non-occurrence of trade retaliation of the 2008 lies in the overly simple models used in earlier optimal tariff literature.

The hierarchy of models we use to show the shrinking optimal tariffs run from a pure exchange Armington to a homogeneous goods model with production. Then we add features of cross border ownership of capital, multi-country models, pairwise trade costs, added trade imbalances, and the lastly homogeneous goods structures. Each of the steps generates a reduction in computed optimal tariffs. These we suggest supports our theme of the overstatement in literature of the threat of trade retaliation at times of financial crisis as in 2008.

The paper is structured as follows. In the second section we review literature on the 1930s and on optimal tariffs. The next section describes our model experiments and we discuss the concepts of observation equivalence and supporting parameterizations in the hierarchy of nested models we use. We then calculate optimal tariffs with different model structures. The last see our conclusions.

2. Literature Review

The Great Depression of the 1930s is widely believed to be marked by an outbreak of severe protection trade policies. The proliferation of higher tariffs, import quotas, and foreign exchange controls are then all thought to have contributed to a collapse of international trade. These import restrictions, combined with preferential trade blocs are thought to have, destroyed the relative open, non-discriminatory world trading system (Irwin, 2012). A numbers of papers explore role of various factors in the trade collapse in the 1930s. Barry and Sachs (1985) analyze exchange rates and their influence to economic recovery. Kindleberger (1986) explores the 1929-1939 world trade depression. Hamilton (1987) studies monetary factors in the Great Depression. Bernanke (1995) analyzes the macroeconomics of the Great Depression. Eichengreen and Irwin (1995) study world trade in 1930s involving trade blocs and currency blocs. A rise in protectionism in 1930s is in most accounts of the period, some countries raised tariffs sharply, they also imposed controls on foreign exchange transactions, while others tightened trade restrictions only marginally (Eichengreen and Irwin, 2010).

Optimal tariffs are related to this literature. We show a shrinking optimal tariffs follows by adding more realistic modelling assumptions into the model structure and perhaps explains why the 2008 financial crisis avoided retaliatory trade intervention. How different model structures influence optimal tariff is the main contribution of this paper. First, we offer a review literatures of optimal tariff literature.

Optimal tariff literature is not as voluminous as work on other trade topics. Graaf (1949-1950), Johnson (1953-1954), Gorman (1958) and Kuga (1973) are early papers which analyze optimal tariffs in two-country pure exchange models and conclude that optimal tariffs equal the inverse of the export supply elasticity. Eaton and Grossman (1985) analyzes optimal tariffs when domestic markets are incomplete. Kennan and Riezman (1988) show theoretically that big countries can win tariff wars and have larger optimal tariffs. Lapan (1988) takes account of production and consumption when analyzing optimal tariffs. Grossman and Helpman (1995) introduce political economy considerations to explore the structure of protection in non-cooperative and cooperative tariff policy equilibria. Syropoulos (2002) analyzes how and why monopoly power and country size influence optimal tariffs.

Later numerical studies of optimal tariffs can be divided into two parts. One uses econometric methodology to calculate optimal tariffs. As the optimal tariff equals the inverse of the export supply elasticity, papers compute optimal tariffs by estimating inverse export supply elasticities. Broda *et al.* (2008), for instance, build an optimal tariff theory for a new trade theory structure (imperfect competition and scale economies) and calculates export supply elasticities and optimal tariffs. Soderbery (2014) assumes that exporters have heterogeneous supply elasticities and estimates these elasticity values with a structural estimator, and then computes optimal tariffs.

The second part uses numerical model calibration and simulation methodology to calculate optimal tariffs. Hamilton and Whalley (1983) were the first to numerically calculate optimal tariffs with general equilibrium (GE) using calibration and simulation methods. Markusen and Wigle (1989) calculate bilateral optimal tariffs for the US and Canada, and explore the roles of country size, scale economies and capital mobility for Nash equilibrium tariffs. Perroni and Whalley (2000) calculate post-retaliation Nash tariffs by region and use them to analyze country gains and losses from regional agreements and trade liberalization. Ossa (2011) calculates non-cooperative tariffs numerically in a "new trade" theory structure and analyzes GATT/WTO negotiations. Whalley et al. (2011), Yu and Zhang (2011) use an inside money trade imbalance model structure to numerically calculate optimal tariffs. More recently Ossa (2014) uses a "new trade" model structure and incorporates political economy factors to numerically calculate optimal tariff, trade war equilibrium tariff and trade talk equilibrium tariff.

Early theoretical papers conclude that optimal tariffs simply equal the inverse of the export supply elasticity. Beyond this, none of them explores the influence of model structure on optimal tariffs in a comprehensive way. This paper uses different model structures to numerically calculate optimal tariffs and shows that more realistic assumptions in the model can generate sharply lower optimal tariffs, which can perhaps help explain why retaliatory trade intervention did not occur in the 2008 financial crisis.

3. GE Models, Data, Calibration and Calculation of Optimal Tariffs

We describe our numerical general equilibrium (GE) models, benchmark data used for calibration and counterfactual simulation, and optimal tariff calculation methodology in this part.

3.1 General Equilibrium Model Structures

We use different model structures to calculate optimal tariffs, from Armington goods general equilibrium models to homogeneous goods general equilibrium models. For the Armington goods models, we begin with pure exchange structures and gradually include production and foreign ownership of capital, then we extend to multi-country model structures and include trade cost, exogenous trade imbalance and monetary trade imbalance step by step. For the Homogeneous goods models, we have pure exchange structure, with production GE structure, and exogenous fixed trade imbalance structure with production.

3.1.1 Simple Armington Goods GE Models

The basic structure of our simple models have two countries, two goods (manufacturing goods and non-manufacturing goods) and two input factors (labor and capital), see Figure 1. Simple Armington goods GE models include pure exchange structure and with production structure.

In the pure exchange models group, two countries are sequentially and separately identified as the US and ROW (Rest of the World), the EU (European Union) and ROW, and China and ROW. The two goods are manufacturing goods and non-traded non-manufacturing goods. Each country has an endowment of goods. We assume preference functions are CES (Constant Elasticity of Substitution) style. In the Armington goods models, goods from different countries are heterogeneous and there is an elasticity of substitution, in the preference function which is two-level CES. In the equilibrium, goods markets will clear, and goods prices are determined by demands and supply.

In simple GE models with production, both production and consumption are included. The models are again two-country two-goods and two-factor structures. The preference functions are two-level CES, the production functions are CES (see Figure 1). In the equilibrium, goods and factor markets in every country clear.

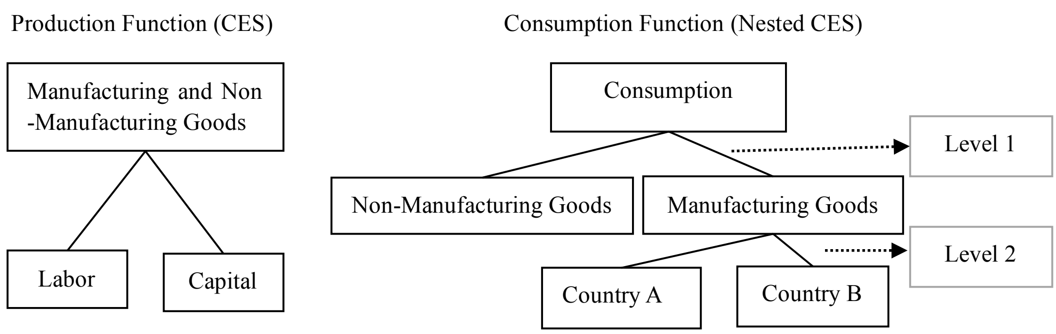

Figure 1: Nesting Structure of Simple Armington Goods GE Models

Source: Compiled by authors.

In these simple models, trade are balanced, which means every country's total exports equals its total imports in value terms.

3.1.2 Simple Armington Models with Foreign Ownership of Capital

We add foreign ownership of capital assumption into simple Armington general equilibrium model with production. Basic structures are two-country two-goods and two-factor general equilibrium, where labor is mobile between industries but immobile between countries. In order to introduce foreign ownership of capital assumption, we assume that capital is mobile between both industries and countries, which means capital used in the production may come from either domestic country or foreign country. Under this assumption, the production and consumption function structures are shown in Figure 2.

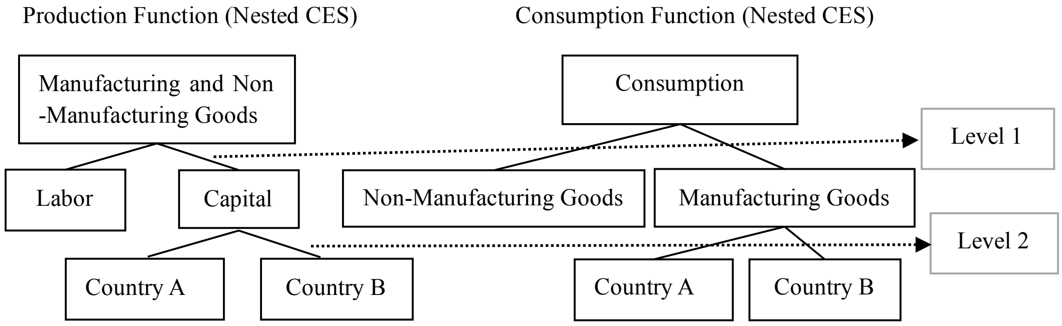

Figure 2: Nesting Structure of Simple Models with Capital Foreign Ownership

Source: Compiled by authors.

There are some different methods to incorporate international ownership of capital into a global applied general equilibrium model. Francois et al. (1996) and Walmsley (1998) attempts at simple comparative static models. Willenbrockel (1999) uses a two-country model to incorporate capital cross-ownership. Ianchovichina and McDougall (2001), and Walmsley (2002) extend the structure in the dynamic GTAP model. These assumptions regarding capital mobility differ significantly. The method for incorporating foreign ownership of capital in our paper are simple and directly. We assume that capital are homogeneous and mobile between countries, capital demand in the production may come from different countries.

3.1.3 Multi-country Armington GE Models

In the multi-country GE model, all of production and consumption structures are the same as the simple two-country case with production in our paper, only extension is that the model here has more countries, specifically we have seven countries which are China, the US, the EU, India, Japan, Brazil and ROW.

3.1.4 Multi-country Armington Models with Trade Cost

All production and consumption side structures are the same as in multi-country models. Trade cost can be divided into tariff and non-tariff barrier, tariff generate revenue but non-tariff barrier does not generate revenue. We assume importers need to use real resources to cover the non-tariff costs involved, these resource costs are denominated in terms of domestic non-manufacturing goods. We incorporate this resource using feature through use of non-manufacturing goods equal in value terms to the cost of barriers.

3.1.5 Multi-country Armington Models with Trade Imbalance

There are two trade imbalance modelling methods; exogenous fixed trade imbalance, and endogenous monetary trade imbalance.

(1) Exogenous Fixed Trade Imbalance GE Model

Exogenous fixed trade imbalance general equilibrium structure is a traditional assumption, which assumes that trade imbalances for all countries are fixed all the time. We assume an exogenously determined fixed trade imbalance, denoted as S_i, which will be positive when in trade surplus and negative when in trade deficit. Trade equilibrium will influence individual country's budget constraint. In the equilibrium, we have

$$I_i = E_i + S_i \qquad (1)$$

which means that one country's total income (I_i) equals its total consumption expenditure (E_i) plus its surplus (trade imbalance), if one country has trade surplus then its income will more than consumption expenditure, but if one country has trade deficit than its income will be less than consumption expenditure.

(2) Monetary Endogenous Trade Imbalance GE Model

Monetary endogenous trade imbalance general equilibrium models 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 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

$$S_i = I_i - \overline{M}_i \qquad (2)$$

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

$$\sum_i S_i = 0 \qquad (3)$$

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

3.1.6 Homogeneous Goods GE Models

All homogeneous goods models in this paper have the structure of two-country and two-goods, two countries have three different groups which are the US and ROW, the EU and ROW, and China and ROW. The two goods are manufacturing goods and non-traded non-manufacturing goods.

In the pure exchange structure, each country has an endowment of goods. One country trades one good with the other country, and the same good in the two countries has the same price. In the equilibrium, all goods will be consumed, each country's total export value equals its import value. In the equilibrium, goods markets will clear, and goods prices are determined by demands and supply.

In the balanced trade GE with production models, we include production into the homogeneous goods pure exchange mode, in order to avoid specialization problems, we use fixed sector specific inputs and diminishing marginal productivity production functions in which the marginal productivity of labor equals zero as output in the sector approaches zero. Here, labor is only factor in production, capital is not included. In the equilibrium, goods and factor markets in every country clear.

Then we extend the model to include trade cost by adding non-tariff barriers into the model, and assume that non-tariff barriers are covered by non-tradable non-manufacturing goods. We also extend the model to unbalanced trade. This group of models have the same structure as the balanced trade models above, the only difference being we capture unbalanced trade. We include an exogenous fixed trade imbalance structure into the general equilibrium model, in which each country's trade imbalance is fixed and total world trade is balanced.

We compile and compare these different model structures in Table 1.

Table 1: Model Structures Used for Calculating Optimal Tariffs

Type	Model Structures	Production Function	Consumption Function	Main Features
Armington Assumption Models	Pure Exchange Simple Model	None	2-level Nested CES	Only has consumption side
	Simple Model with production	1-level CES	2-level Nested CES	Typical 2-2-2 model
	Simple Model with Production and Capital Foreign Ownership	2-level Nested CES	2-level Nested CES	Include capital flow
	Multi-country Model	1-level CES	2-level Nested CES	Typical n-2-2 model
	Multi-country Model with Trade Cost	1-level CES	2-level Nested CES	Include tariff and non-tariff barrier
	Multi-country Model with Exogenous Trade Imbalance	1-level CES	2-level Nested CES	Fixed trade imbalance
	Multi-country Model with Monetary Trade Imbalance	1-level CES	2-level Nested CES	Endogenous trade imbalance
Homogenous Goods Models	Pure Exchange Simple Model	None	1-level CES	Consumption goods from different countries are homogenous
	Simple Model with Production	fixed sector specific inputs and diminishing marginal productivity production function	1-level CES	Production functions are used to avoid specialization problem
	Simple Model with production and Exogenous Trade Imbalance	fixed sector specific inputs and diminishing marginal productivity production function	1-level CES	Trade are unbalanced and unique production function

Source: compiled by authors.

3.2 Benchmark Data and Calibration

We use 2013 as our base year in building a global benchmark general equilibrium dataset for use in calibration and simulation using our model variants following the methods set out in Shoven and Whalley (1992). Optimal tariffs are calculated for country pairs, which means only two countries are involved in computation. For two-country models, we have the US-ROW group, the EU-ROW group and China-ROW group. For multi-country models, there are seven countries in our data set, which are the US (United States), the EU (European Union), China, India, Japan, Brazil and ROW (Rest of the World).

Country group data are obtained by adding individual country data together. ROW data is obtained by using total world values minus values for all other countries. For the two goods, we assume secondary industry (manufacturing) reflects manufacturing goods, and primary and tertiary industries (agriculture, extractive industries, and services) yield non-traded non-manufacturing goods. For the two factor inputs, capital and labor, we use total labor income (wage) to denote labor values for inputs by sector. All data are in billion US dollars.

All data are from the World Bank database (World Development Indicate). 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 ratios to yield capital and labor input in production. These data are listed in Table 2. We adjust some of the data for mutual consistency for calibration purposes.

Table 2: Data Used For Calibration and Simulation (2013 Data)

Country	GDP	Tradable	Non-tradable	Capital Used in Production		Labor Used in Production	
				Tradable	Non-tradable	Tradable	Non-tradable
China	9240.3	4065.7	5174.6	1992.2	2535.5	2073.5	2639.1
US	16768.1	3521.3	13246.8	704.3	2649.3	2817	10597.5
EU	17972.9	5571.6	12401.3	1114.3	2480.3	4457.3	9921
India	1876.8	469.2	1407.6	145.1	436.7	324.1	970.9
Japan	4919.6	1279.3	3640.3	269	764.1	1010.3	2876.2
Brazil	2245.7	561.4	1684.3	101	303.2	460.4	1381.1
ROW	22568.6	7447.7	15120.9	2606.7	5292.4	4841	9828.5
World	75592	22916.2	52675.8	6932.6	14461.5	15983.6	38214.3

Note: (1) Units for production, capital, labor and endowments are all billion US$, and labor here denotes factor income (wage). (2) We use world values minus all individual countries to generate ROW values.

Sources: calculated from WDI of World Bank database.

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, and add individual country trade data to yield country group's trade data. For trade balanced models, we use total export data to adjust total import data to make them equal, and then adjust trade with ROW to make each country's trade balanced. For imbalanced trade models, we use real export, import and imbalance data in calibration and simulation. Using production and trade data, we can then calculate each country's consumption values. The trade data we use are listed in Table 3.

Trade costs have 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 use world average tariff rates to denote these values. Import tariffs data are listed in Table 4. We can then get non-tariff barriers by using trade costs minus import tariffs.

Table 3: Trade between Countries in 2013 (Unit: Billion USD)

Country		Exporter							
		China	US	EU	India	Japan	Brazil	ROW	Total
Importer	China	0	153.4	196.8	16.9	162.3	54.3	1366.2	1949.9
	US	369.1	0	382.5	43.3	134.5	28.6	1370.3	2328.3
	EU	371.9	260.1	0	48.9	75.1	43.8	1443.6	2243.4
	India	48.4	21.9	47.6	0	8.6	3.8	335.8	466.1
	Japan	150.1	71.9	71.6	7.1	0	7.9	524.6	833.2
	Brazil	35.9	44.1	53.2	6.1	7.1	0	93.2	239.6
	ROW	1233.7	1026.7	1574.6	214.3	327.5	103.8	0	4480.6
	Total	2209.1	1578.1	2326.3	336.6	715.1	242.2	5133.7	/

Notes: We get the ROW trade data by deducting from each country's total export, total import and total world trade value.

Sources: United Nations (UN) Comtrade database.

Table 4: Import Tariffs for Countries in 2013 (Unit: %)

Country	China	US	EU	India	Japan	Brazil	ROW
Tariff	9.9	3.4	5.5	13.5	4.9	13.5	8.5

Notes: (1) Import tariffs here are simple average MFN applied tariff rates. (2) We use import tariff of the world to denote the tariff for the ROW.

Source: WTO Statistics Database.

We calculate trade costs following the approaches in Novy (2013), Wong (2012), and Li and Whalley (2014). Calculation results are shown in Table 5[1]. Non-tariff barriers can then be calculated by using trade cost minus import tariffs.

Table 5: Ad Valorem Tariff-Equivalent Trade Costs Between Countries in 2013 (Unit: %)

Country	China	US	EU	India	Japan	Brazil	ROW
China	0	57.5	55.4	77.1	53.4	70.8	29.5
US	57.5	0	59.8	83.9	69.9	83.7	37.1
EU	55.4	59.8	0	74.5	76.3	77.3	33.4
India	77.1	83.9	74.5	0	100.8	103.6	42.9
Japan	53.4	69.9	76.3	100.8	0	105.1	44.1
Brazil	70.8	83.7	77.3	103.6	105.1	0	63.8
ROW	29.5	37.1	33.4	42.9	44.1	63.8	0

Source: Calculated by authors.

When the models include the foreign ownership of capital assumption, foreign direct investment

[1] Detailed trade cost calculation methodology is described in an Appendix.

(FDI) data and overseas direct investment (ODI) data are needed. We get these data from the UNCTAD FDI/TNC database (see Table 6). In the models with the foreign ownership of capital assumption, capital input in production comes from both domestic countries and foreign countries, we assume these capital are homogenous. In the models without the foreign ownership of capital assumption, capital input in production are all from domestic endowment.

Table 6: FDI and ODI in 2013 (Unit: Billion US$)

Country	China	US	EU	India	Japan	Brazil	ROW
FDI	1343.6	1650.8	5313.6	218.1	205.8	646.9	7240.3
ODI	531.9	4453.3	6642.2	79.9	1037.7	266.3	4607.8

Source: UNCTAD FDI/TNC Database.

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 (Betina *et al.*, 2006), so we set all these elasticities in our model to 2 (Whalley and Wang, 2010). We perform sensitivity analysis around these elasticities.

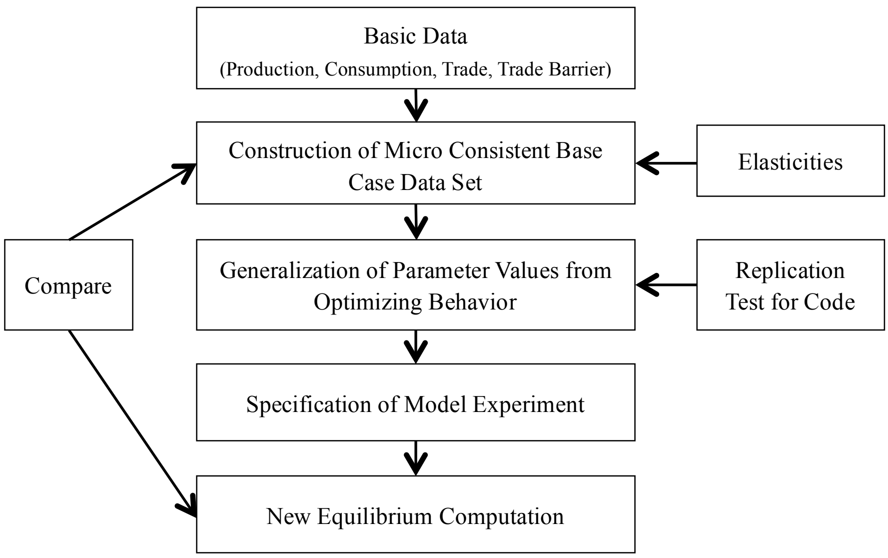

Figure 3: Flow Chart for Calibration

Source: Compiled by authors.

With these data, we calibrate the model parameters for each model structure. When used in model solution these regenerate the benchmark data as an equilibrium for the model. Then, using these parameters we can form a numerical global general equilibrium system, and can use this system to calculate optimal tariff. Figure 3 shows the calibration process.

3.3 Optimal Tariff Calculations

We consider two different optimal tariffs following Hamilton and Whalley (1983). One is "first step" optimal tariff, we call it optimal tariff without retaliation here; the other is post retaliation optimal tariff, and we call it optimal tariff with retaliation in this paper.

(1) *Optimal tariff without retaliation* refer to tariffs countries would choose given all other countries' factual tariffs (Ossa, 2014). For country i, equilibrium is defined by a vector of world market prices p^* such that country i maximizes their welfare function subject to the general equilibrium conditions:

$$MaxU_i(p_i^*, t_i) \quad s.t.\ GE \qquad i = country \tag{4}$$

where p_i^* denotes the vector of consumption prices in country i, and equilibrium is supported by the optimal tariff t_i of country i. Consumer and government budget balance, and external sector balance should hold in equilibrium.

(2) *Optimal tariff with retaliation* refer to tariffs countries would choose after mutual retaliation and reach a steady equilibrium that no countries will move. This is actually a Nash non-cooperative equilibrium. For country i, equilibrium is defined by a vector of world market prices p^* such that all countries maximize their welfare function subject to the general equilibrium conditions:

$$\begin{aligned} &Max\ \ U_i(p_i^*, t_i)\ \ ,\ \ \forall i \\ &\quad s.t.\ GE \qquad i = country \end{aligned} \tag{5}$$

where p_i^* denotes the vector of consumption prices in country i, and equilibrium is supported by the optimal tariff t_i in all countries. Consumer and government budget balance, and external sector balance all hold in equilibrium.

In computation, we assume that the predetermined direction of trade remains unchanged in the face of tariff retaliation. We follow the process of retaliation through which optimal tariffs are calculated by each country, and revised in light of any changes in tariffs adopted by the other country. When no further retaliation occurs, an approximation to the Nash equilibrium is achieved. In calculation optimal tariff with retaliation (non-cooperative Nash equilibrium), we iterate over calculations of optimal tariff by individual country to tariff settings of other countries subject to the constraint of full general equilibrium within the period. We then iterate across country tariffs until convergence to a non-cooperative Nash equilibrium is achieved. Convergence appears to be rapid in all the cases we have examined and the amounts of execution time involved are small.

4. Optimal Tariffs Computational Results

We divide and report optimal tariff computation results with six parts. The first is optimal tariffs with pure exchange models, the second is optimal tariffs with simple Armington assumption models, the third is optimal tariffs with multi-country Armington assumption models, the fourth is optimal tariffs with homogenous goods models, the fifth is sensitivity analysis, and the last is overall analysis and comparison.

4.1 Optimal Tariffs with Pure Exchange Models

The basic structure for computing optimal tariffs of homogeneous goods and Armington goods is the pure exchange model. We compute optimal tariffs for homogeneous goods pure exchange model and compare them with Armington goods model structures. Results are reported in Table 7.

Table 7: Optimal Tariffs of Pure Exchange GE Models (Unit: %)

Countries	OT Without Retaliation	OT With Retaliation	OT Without Retaliation	OT With Retaliation
	Homogeneous Goods Models		***Armington Goods Models***	
	China-ROW Retaliation		China-ROW Retaliation	
China	8.3	5.5	109.8	103.8
ROW	41.9	44.9	161.4	127.5
	US-ROW Retaliation		US-ROW Retaliation	
US	5.9	4.4	106.2	102.5
ROW	18.6	18.2	144.6	118.4
	EU-ROW Retaliation		EU-ROW Retaliation	
EU	9.0	6.5	110.7	104.4
ROW	27.2	26.7	140.6	117.1

Source: calculated and compiled by authors.

The results show that optimal tariffs under Armington goods structure are much higher than under homogeneous goods structure. We take the China and ROW country pair as an example, China's optimal tariff without retaliation in homogeneous goods model is 8.3%, and is 109.8 in Armington goods model; ROW's optimal tariff without retaliation in homogeneous goods model is 41.9%, and is 161.4% in Armington goods model. Figure 4 gives a sensitivity analysis comparison to elasticities for China-ROW case, it is clear that Armington goods structure will generate high optimal tariffs.

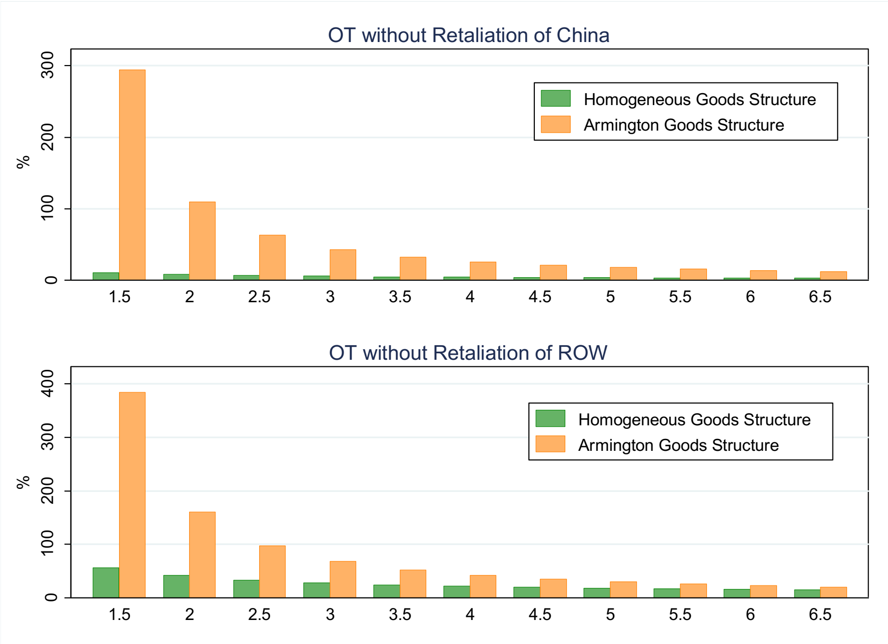

Figure 4: OT of China-ROW Retaliation under Pure Exchange Models with Different Elasticities (%)

Source: Compiled by authors.

The analysis in this part suggests that optimal tariffs in models with the Armington assumption are significantly larger than the ones with homogeneous goods assumption, and that the Armington assumption produces a large upward bias regarding optimal tariffs. As computations for Armington type models have been the basis for the belief that trade retaliation, if unchecked, will lead to both very high tariff and a sharp decline of trade, the behavior of major global economies in the 2008/2009 crisis is seen as hard to explain.

4.2 Optimal Tariffs Variation with Simple Armington Assumption GE Models

We start with simple Armington goods models and gradually add more realistic assumptions into the model. Simple Armington goods models have the pure exchange structure and general equilibrium with production structure. We assume a 2-country and 1-goods structure for pure exchange model, and assume both a 2-country and 1-goods structure and a 2-country and 2-goods structure for GE with production model. We compute both optimal tariff without retaliation and optimal tariff with retaliation. Table 8 report these results.

We compare the results of pure exchange GE models with models with production, and find that models with production will generate a smaller optimal tariff compared with pure exchange models. But comparatively, the gap of optimal tariffs between pure exchange models and models with production are smaller, which means models with production cannot generate huge deduction on optimal tariff. Meanwhile, we also find that two-goods model structures will generate slightly smaller optimal tariffs compared with one-goods model structures.

We compare optimal tariffs for models with foreign ownership of capital and without foreign ownership of capital, and find that when we incorporate foreign ownership of capital, optimal tariffs will decrease sharply. Meanwhile, optimal tariff level will be influenced by the net capital balance position, net capital surplus countries will have larger optimal tariff. Under the influence of net capital balance, bigger countries are not always have larger optimal tariffs. Therefore, models with foreign ownership of capital will significantly lower optimal tariff.

Simple Armington assumption GE models show a gradually decreasing optimal tariffs as we add more realistic features into the model. Foreign ownership of capital assumption has significant and prominent negative effects to optimal tariffs, including production side into the model also has negative influence to optimal tariffs. These results show that more realistic features will generate gradually lower optimal tariffs, which is helpful for explaining why the 2008 financial crisis had not cause retaliatory trade intervention.

Table 8: Optimal Tariffs under Different Model Structures (Unit: %)

Types	Countries	OT Without Retaliation	OT With Retaliation	OT Without Retaliation	OT With Retaliation	OT Without Retaliation	OT With Retaliation	OT Without Retaliation	OT With Retaliation
Armington Assumption Structures (2-Country Cases)		***Pure Exchange***		***1-Goods With Production***		***2-Goods With Production***		***With Capital Foreign Ownership***	
		China-ROW Retaliation		China-ROW Retaliation		China-ROW Retaliation		China-ROW Retaliation	
	China	109.8	103.8	108.4	103.4	102.4	100.9	33.1	32.4
	ROW	161.4	127.5	151.6	123.1	119.2	108.6	32.3	31.1
		US-ROW Retaliation		US-ROW Retaliation		US-ROW Retaliation		US-ROW Retaliation	
	US	106.2	102.5	105.5	102.2	102.5	101.1	11.3	11.1
	ROW	144.6	118.4	140.5	116.7	108.6	103.6	10.1	9.7
		EU-ROW Retaliation		EU-ROW Retaliation		EU-ROW Retaliation		EU-ROW Retaliation	
	EU	110.7	104.4	109.3	103.8	102.8	101.2	21.4	20.5
	ROW	140.6	117.1	136.0	115.1	109.5	104.0	18.0	17.2
Armington Assumption Structures (Multi-Country Cases)		***Multi-country Model***		***With Trade Cost***		***With Exogenous Trade Imbalance***		***With Endogenous Trade Imbalance***	
		China-US Retaliation		China-US Retaliation		China-US Retaliation		China-US Retaliation	
	China	33.8	35.5	39.4	40.8	31.2	31.9	10.8	10.2
	US	39.0	39.6	51.2	51.6	16.5	16.5	3.3	3.4
		China-EU Retaliation		China-EU Retaliation		China-EU Retaliation		China-EU Retaliation	
	China	34.7	36.4	40.4	40.8	32.0	33.6	10.6	10.1
	EU	40.4	41.1	50.2	50.7	42.3	43.0	5.4	5.5
		China-ROW Retaliation		China-ROW Retaliation		China-ROW Retaliation		China-ROW Retaliation	
	China	54.7	55.4	83.9	84.6	49.9	50.9	10.0	10.0
	ROW	35.8	39.5	51.9	56.6	62.4	69.6	8.5	8.5
Homogenous Goods Structures		***Pure Exchange***		***With Production***		***With Trade Cost***		***With Exogenous Trade Imbalance***	
		China-ROW Retaliation		China-ROW Retaliation		China-ROW Retaliation		China-ROW Retaliation	
	China	8.3	5.5	3.1	1.8	3.7	1.5	3.0	1.7
	ROW	41.9	44.9	21.5	20.6	26.0	32.9	20.7	19.8
		US-ROW Retaliation		US-ROW Retaliation		US-ROW Retaliation		US-ROW Retaliation	
	US	5.9	4.4	2.4	1.6	3.2	1.8	3.2	2.1
	ROW	18.6	18.2	5.0	4.3	6.4	5.0	6.5	5.6
		EU-ROW Retaliation		EU-ROW Retaliation		EU-ROW Retaliation		EU-ROW Retaliation	
	EU	9.0	6.5	3.6	2.4	4.6	2.5	3.6	2.2
	ROW	27.2	26.7	6.9	6.0	9.4	6.8	6.9	5.8

Source: calculated and compiled by authors.

4.3 Optimal Tariffs Variation with Multi-country Armington Assumption Models

We extend the model from a two-country structure into a Multi-country structure and explore optimal tariffs. As the traditional optimal tariff issues are discussed in a two-country horizontal, so we keep on exploring optimal tariffs within two-country pairs even though the model structure has extended to multi-country cases. We select three different country pairs for research, which are China-US, China-EU, and China-ROW. We gradually extend to include trade cost, exogenous fixed trade imbalance, and endogenous monetary trade imbalance.

We firstly compute and compare optimal tariffs under multi-country model with the ones under two-country model. The results are clear that optimal tariffs under multi-country structure are significantly smaller (see Table 8). We take China-ROW case as an example to compare results. Optimal tariff without retaliation under multi-country structure of China-ROW retaliation for China and ROW are separately 54.7% and 35.8%, but are separately 102.4% and 119.2% under two-country structure.

We next include trade cost into the multi-country model, and find that multi-country model with trade cost will generate a slightly bigger optimal tariff compared with model without trade cost (see Table 8).

Then we extend the multi-country global general equilibrium model to incorporate trade imbalance and compute optimal tariffs, and then explore how trade imbalance structure influence optimal tariffs. We use two trade imbalance modelling methods in our computation, which are exogenous fixed trade imbalance and endogenous monetary trade imbalance.

We find that optimal tariffs under multi-country exogenous trade imbalance model are smaller than under multi-country trade balance model. Meanwhile, bigger countries are not always having larger optimal tariff under exogenous trade imbalance structures (see Table 8). It seems that optimal tariff are influenced by imbalance positions, trade surplus countries have lower optimal tariff but trade deficit countries have larger optimal tariffs.

We move to the endogenous monetary trade imbalance model structures, and it is obvious that optimal tariffs under multi-country GE models with monetary trade imbalance are prominently lower than trade balance models (Table 8). Meanwhile, it seems bigger countries do not have larger optimal tariffs, and it is not clear whether trade imbalance influence optimal tariffs.

This part computation results also show a gradually decline optimal tariffs when we add more realistic features into the model. Lower trade cost generate lower optimal tariffs, trade imbalance and especially endogenous trade imbalance structure have prominent negative effects to optimal tariffs. These more realistic features with lower optimal tariffs reveal that the 2008 financial crisis will not lead to retaliatory trade intervention.

4.4 Optimal Tariff Variations with Homogenous Goods Models

We move to the homogeneous goods GE model structure in this part. The basic structure of homogeneous goods is pure exchange model, and then we incorporate more assumptions into homogeneous goods models and explore their influence on optimal tariffs. These more assumptions are separately production, trade cost and exogenous fixed trade imbalance.

For the production function in homogeneous goods, we use structures with fixed sector specific inputs and diminishing marginal productivity of mobile across sector labor. The model avoids specialization by using a construction in which the marginal productivity of labor equals zero as output in the sector approaches zero. For the trade cost feature, we introduce non-tariff barriers into the model. For the trade imbalance features, we use exogenous fixed trade imbalance structures. In the homogeneous structures, only labor factors are needed in fixed sector specific inputs production function, so the assumption of foreign ownership of capital cannot be included in the structure.

Results of homogeneous goods general equilibrium models with production show significantly lower optimal tariffs compared with pure exchange structures. Lower trade cost receives a little smaller optimal tariffs, and including fixed trade imbalance assumption generates further lower optimal tariffs. These results prove that when we include more realistic features into the model, trade retaliation or retaliatory trade intervention will not take place again.

4.5 Sensitivity Analysis on Elasticities

We do sensitivity analysis of optimal tariffs to elasticities by changing the elasticities from 0.5 to 6.5 in this part. We only choose homogeneous goods pure exchange models and simple Armington goods pure exchange models to perform sensitivity analysis, and we only calculate OT without retaliation for simplicity. All results are reported in Table 9.

Table 9: Sensitivity of Optimal Tariff to Elasticities with Pure Exchange Models (%)

Country/Elasticity		0.5	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
Homogeneous Goods and Pure Exchange Models													
China-ROW	China	35.9	10.9	8.3	6.7	5.7	4.9	4.4	4.0	3.6	3.4	3.1	2.9
	ROW	216	56.7	41.9	33.6	28.3	24.7	22.0	19.9	18.3	17.0	15.9	15.0
US-ROW	US	22.9	7.7	5.9	4.8	4.1	3.6	3.2	3.0	2.7	2.5	2.4	2.2
	ROW	84.6	24.4	18.6	15.3	13.2	11.7	10.6	9.8	9.1	8.5	8.1	7.7
EU-ROW	EU	39.6	11.9	9.0	7.2	6.1	5.3	4.7	4.3	3.9	3.6	3.4	3.2
	ROW	118	35.7	27.2	22.3	19.1	16.9	15.3	14.0	13.0	12.2	11.5	11.0
Armington Goods and Pure Exchange Models													
China-ROW	China	133	294	110	62.8	43.0	32.3	25.7	21.2	18.0	15.6	13.7	12.2
	ROW	17303	384	161	97.7	68.8	52.6	42.3	35.3	30.1	26.2	23.2	20.7
US-ROW	US	74.5	239	106	62.0	42.9	32.5	26.0	21.6	18.4	16.0	14.1	12.6
	ROW	9599	341	145	87.4	61.4	46.7	37.4	31.1	26.4	22.9	20.1	17.9
EU-ROW	EU	79.8	285	111	64.6	44.7	33.8	26.9	22.3	19	16.5	14.5	12.9
	ROW	14795	335	141	84.6	59.3	45.1	36.1	29.9	25.4	22	19.4	17.2

Notes: "China-ROW" denotes the case of China-ROW mutual retaliation; "US-ROW" denotes the case of US-ROW mutual retaliation; "EU-ROW" denotes the case of EU-ROW mutual retaliation.

Source: calculated and compiled by authors.

We find that as elasticities increase, all optimal tariffs for individual countries decrease in both homogeneous goods and Armington goods structures. Sensitivity of elasticity analysis also proves that Armington goods structure will generate higher optimal tariff than homogeneous goods structure.

4.6 Overall Comparison of Optimal Tariffs

Our computation with different model structures show a continuously drop optimal tariffs. When we switch the models from Armington assumption structure to homogenous goods structure, and change the models from two country to multi-country, optimal tariffs will decreasing greatly and significantly. Meanwhile, when we add more realistic features, including production, lower trade cost, trade imbalance, and foreign ownership of capital into the model, optimal tariffs will further decrease step by step. These declining optimal tariff results prove that as the deepening of globalization and economic integration, retaliatory trade intervention is no longer a good choice for countries in crisis, which is why the 2008 financial crisis had not run into retaliatory trade intervention.

5. Conclusions

This paper aims to explain why the 2008/2009 financial crisis had not caused global retaliatory trade interventions by showing gradually shrinking optimal tariffs with different model structures and more realistic model features added.

We consider two different kinds of optimal tariffs without retaliation and with retaliation, and compute them separately under different model structures. We separate all model structures into three groups, which are simple Armington assumption GE models, multi-country Armington assumption GE models and homogenous goods GE models. Under each group of models, we add realistic features and assumptions step by step, including trade cost, trade imbalance and foreign ownership of capital.

Our research results reveal that homogeneous goods GE models generate much lower optimal tariff compared with Armington assumption GE models, multi-country GE models generate significant lower optimal tariffs compared with two-country GE models. Structures with production, lower/no trade cost, endogenous trade imbalance and foreign ownership of capital all will generate sharply lower optimal tariffs.

Optimal tariffs are closely related to retaliatory trade policy, countries choose a low optimal tariff means they will not choose trade retaliation. Our numerical calculation results show that when we incorporate more realistic assumptions into the GE model will generate a shrinking optimal tariffs. This means that as claimed reality changes, retaliatory trade intervention is no longer in an individual country's interest in financial crisis, which is the reason why the 2008 financial crisis had not generated retaliatory trade intervention.

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