Can Protectionism Improve the Trade Balance?

Sunghyun Henry Kim
Department of Economics
Sungkyunkwan University

Serge Shikher
U.S. International Trade Commission

October 2018

Introduction

- There is a newfound interest in the macroeconomic effects of trade policies
  - Effects of tariffs, subsidies, border-adjustment tax (BAT) on the trade balance
  - Effects of free-trade agreements on the trade balance
  - Effects of trade policy on employment
- More economic and quantitative analysis is needed to inform these debates.

Challenges

Analysis of these topics requires model with a good representation of

- Macroeconomic phenomena
  - Modeling of international financial markets is key
- International trade
  - Model needs to include multiple countries and industries

A model with these features presents significant computational challenges

Macroeconomic features of the model

- Inter-temporal allocation of resources
  - Via optimization by households
- Endogenous factor prices, labor supply, employment
- Realistic representation of international asset markets (next slide)

These features allow us to analyze short-run and long-run effects of trade policy on the following inter-temporal phenomena:

- Savings and investment
- Trade balance and foreign asset positions
- Labor force participation

International financial markets

Financial markets are incomplete

- Countries can buy each other's noncontingent bonds
- A key feature of the model
- Needed to have a realistic model of trade balance

Other DGE models of trade use an alternative assumption: countries can insure against any eventuality

- Complete financial markets
- This assumption results in zero or very small changes in current account in response to trade policy changes
- The assumption of complete asset markets significantly simplifies model solution, but is not suitable for modeling of trade balance (Obstfeld, 2012)

Features of the model relevant for trade

- Three countries (US, China, ROW)
- Tradable and nontradable sectors
- Two factors of production: labor and capital that is subject to adjustment costs
- Home bias is driven by trade costs and trade is modeled using a gravity equation

These features allow us to model the following responses to a change in trade policy:

- Trade creation and diversion
- Inter-industry reallocation of resources (change in specialization)
- Adjustment paths of these variables between the old and new equilibria

Solution methodology

- A linear approximation method based on a shooting algorithm
  Mendoza and Tesar (1998), Gorodnichenko, Mendoza, and Tesar (2012), and Kim and Kose (2014)
- This method allows us to analyze how one-time permanent changes in tariff rates affect macroeconomic variables in the model over time

Literature

- CGE models - agents do not make decisions on intertemporal reallocation of resources (Kehoe et al, 2016)
- New-Keynesian macro models with two countries, one sector, and incomplete markets
  - Lindé and Pescatori (2017) - Import tariff, export subsidy, and Learner equivalence
  - Erceg et al (2017) - Effects of import tariff, export subsidy, and BAT on output, exchange rate, and inflation
  - Cacciatore and Ghironi (2014) - Effects of trade integration for the conduct of monetary policy
- Model of trade and macro with complete asset markets (Eaton et al, 2016)
- Small open-economy macro models with several industries
  - Artuç et al (2007) - A model of dynamic labor adjustment
  - Kambourov (2008) - Sectoral reallocation of workers
- Multi-sector small open-economy model with incomplete capital markets - Kim and Kose (2014)

Literature

- Effects of trade costs on trade imbalances
  - Obstfeld and Rogoff (2001) - Suggest that trade costs can help explain several puzzles in international macro
  - Coeurdacier (2009), Eaton, Kortum, and Neiman (2016) - Quantitative assessment of OR (2001)
  - Reyes-Heroles (2016) - Declining trade costs during 1970-2007 contributed to increased trade imbalances
  - Alessandria and Choi (2018) - Study the effects of trade costs on the U.S. trade balance since 1980

Simulations

- Model is calibrated for the US, China, and the rest of the world (ROW)
- We analyze the effects of an increase in US tariff on
  - (a) Chinese goods
  - (b) both Chinese and ROW goods
- For each of the above, we consider two possibilities:
  - (1) No retaliation
  - (2) Symmetric retaliation
- We study how an increase in tariff rates in US against import goods from China and/or ROW affect macroeconomic dynamics, especially trade balance and inter-sectoral resource movement
- We try different values of trade elasticity as a robustness check

Preview of results

- An increase in tariff rate decreases consumption of import goods and increases consumption of domestically produced goods
- Trade diversion effects are observed in some cases where the tariff rate is asymmetrically imposed
- There is a shift of resources in US from tradable to nontradable sector and the production of nontradable good increases
- Trade balance improves in the short run (up to around year 13), but turns into slight deficit in the long run
- Magnitude of trade balance improvement is not large
- Trade balance improvement is greater when tariffs are increased on more partners, magnitude of new tariffs is greater, and there is no retaliation
- Due to the temporary improvement in US trade balance, US accumulates foreign assets
- Both savings and investment fall in the US, but the initial fall in investment is greater than the fall in savings

Model

- There are three countries and two sectors
- Sector 1 goods are traded while sector 2 goods are not traded
- We have in mind that country 1 is U.S., 2 is China, and 3 is ROW
- Goods are differentiated by country of production (Armington assumption)
- Shipping goods between countries involves paying trade costs
  (as in the gravity model, trade costs include freight, tariffs, NTMs, and other costs)

Factors of production

- Each sector uses two factors of production: capital and labor
- Capital is specific to each sector
- Labor is mobile between the sectors
- Capital goods are domestically produced
  (this assumption is for simplicity, but can be relaxed)

Economic agents

- The model includes households, firms, and governments
- Households: possess capital and receive labor and rental income from the firm
- Households are able to borrow and lend in international capital markets using one-period risk-free bonds
- The current and financial account balances are endogenous
- Governments: finance an exogenous stream of expenditures through revenues from domestic lump sum taxes and tariffs on imported goods

Households

A representative household in each country n chooses:

- consumption of the composite tradable good, C_{n1t}
  (a CES combination of tradable goods from 3 countries)
- consumption of the nontradable good, c_{n2t}
- labor supply, h_{njt}

to maximize a constant relative risk aversion (CRRA) utility function:

$$\max \sum_{t=0}^{\infty} \beta^t U_{nt}, \text{ where } U_{nt} = \frac{\left(C_{n1t}^{\omega} c_{n2t}^{1-\omega}\right)^{1-\sigma}}{1-\sigma} - \varphi \frac{\sum_j h_{njt}{}^{1+\xi}}{1+\xi}$$

where β is the discount factor, σ, ω, φ, and ξ are parameters

Subject to the budget constraint

$$Y_{nt} + p_{n2t} T_{nt} + P_{n1t} B_{n,t-1} = P_{n1t} C_{n1t} + p_{n2t} c_{n2t} + I_{nt} + R_t P_{n1t} B_{nt}$$

Y_{nt}	total factor income
p_{n2t}	price of sector 2 (nontradable) good produced in n
P_{n1t}	price of the composite tradable consumption good
T_{nt}	net transfers from government in a lump-sum fashion (assumed to be in nontradable good for simplicity)
I_{nt}	total value of investment
B_{nt}	quantity of discounted bonds purchased in period t (with price R_t, maturing in period $t+1$)

Bonds are priced in terms of sector 1 composite good price P_{n1t}

If we wanted to model financial autarky, B_{nt} would be set to zero in every period

Total factor income of households, Y_{nt}, consists of labor and capital incomes in each sector:

$$Y_{nt} = \sum_j p_{njt}(w_{njt}h_{njt} + r_{njt}k_{njt})$$

where w_{njt}, r_{njt}, k_{njt} are (real) wage, (real) rental rate, and capital
p_{njt} is the price of sector j good produced in country n

Investment spending goes toward buying investment (capital) goods in each sector:

$$I_{nt} = \sum_j p_{njt}i_{njt}$$

where i_{njt} is (real) investment in sector j

Consumers have CES preferences over tradable consumption goods from all countries of origin i:

$$C_{n1t} = \left[\sum_i b_{in} c_{in1t}^{1-\gamma} \right]^{\frac{1}{1-\gamma}}, \ \sum_i b_{in} = 1$$

c_{in1} is the consumption in country n of tradable sector 1 good produced in i
b_{in} is the preference parameter

Another way to interpret the consumption structure:

- Households consume the composite consumption good C_{n1t} which is produced by three intermediate inputs from all countries c_{in1t}
- In this case, the equation above is interpreted as a production function of the final consumption good rather than a preference function

Households in country n accumulate capital in each sector j according to the following equation:

$$k_{nj,t+1} = (1 - \delta_j) k_{njt} + k_{njt} \phi \left(\frac{i_{njt}}{k_{njt}} \right)$$

δ_j is the depreciation rate
ϕ is the adjustment cost function ($\phi' > 0$, $\phi'' < 0$), as in Baxter and Crucini (1993)

Trade costs

- Shipping goods between countries incurs trade costs
- Trade costs are ad-valorem or "iceberg"
- Trade costs include all costs of delivering goods from one country to another, such as freight, insurance, security, tariffs, and non-tariff barriers
- Trade costs are specific to each country pair, direction of trade, and industry
- In order to deliver \$1 of good j to country n, country i must ship $d_{inj} \geqslant 1$ dollars of this good
- We will measure international trade costs relative to domestic trade costs, so $d_{iij} = 1$

- The price of good j produced in country i is p_{ij} when it leaves the factory (producer price or factory-gate price)
- When this product arrives to country n, its price is $p_{injt} = p_{ijt} d_{injt}$ (consumer or delivered price of the good)
- Trade costs are estimated from observed trade flows, as in the gravity literature (explained in a few slides)
- Tariffs are part of trade costs. We denote by τ_{injt} the tariffs imposed by country n on industry j good produced in country i. We have

$$d_{injt} = \tau_{injt} + \overline{d_{injt}},$$

where $\overline{d_{injt}} \geqslant 1$ are all trade costs other than tariffs

Firms

The production function in each country and sector is

$$y_{njt} = A_{njt} k_{njt}^{\alpha_j} h_{njt}^{1-\alpha_j}$$

where A_{njt} is the levels of sector-specific productivity

The no-profit conditions imply that

$$p_{njt} y_{njt} = p_{njt} r_{njt} k_{njt} + p_{njt} w_{njt} h_{njt}$$

for every sector j, country n, and period t

Governments

The government budget constraint is

$$\sum_i \tau_{in1t} p_{i1t} c_{in1t} = p_{n2t} G_{nt} + p_{n2t} T_{nt}$$

Left-hand side is government revenue from tariffs
G_{nt} denotes exogenous government spending
T_{nt} denotes lump-sum fiscal transfers to households
(can be interpreted as lump-sum tax if negative)
We assume that government spending is in nontraded goods only for simplicity
There are no tariffs collected in sector 2 since its good is non-traded

Market clearing conditions

We impose market clearing conditions on all goods in the model
For nontradable sector 2, the market clearing condition for each country n is

$$y_{n2t} = c_{n2t} + i_{n2t} + G_{nt}$$

For tradable sector 1, each country n has the following market clearing condition:

$$p_{n1t} y_{n1t} + P_{n1t} B_{n,t-1} = \sum_i \overline{d_{in1t}} p_{i1t} c_{in1t} + p_{n1t} i_{n1t} + R_t P_{n1t} B_{nt}$$

which can be derived by combining government budget constraint, households budget constraint, and market clearing condition for nontraded good

For tradable sector 1, worldwide resource constrains for each good i are

$$p_{i1t} y_{i1t} = \sum_n \overline{d_{in1t}} p_{i1t} c_{in1t} + p_{i1t} i_{i1t}.$$

This condition, which must hold for each sector i in every period t, says that the value of output must equal to total spending in that sector

Once all three market clearing conditions hold, the following bond market clearing condition holds for every period t (Walras's law):

$$\sum_n P_{n1t}(R_t B_{nt} - B_{n,t-1}) = 0$$

Since the above expression is in fact equal to trade balance, this condition says that trade balance of the three countries should sum up to zero

When we solve the model, we fix the price of sector 1 good in country 1 as 1, which means that p_{11} is the numeraire

Gravity

We derive the theoretical gravity equation:

$$X_{in1t} = \frac{(Y_{i1t} - I_{i1t})\, X_{n1t}}{Y_{1t}} \left(\frac{d_{in1t}}{p_{nt} \Pi_{i1t}} \right)^{\frac{\gamma-1}{\gamma}}$$

It says that bilateral trade flows X_{in1t} are

- proportional to the income of importer i
- proportional to the spending of exporter n
- inversely proportional to the trade cost between them

p_{n1t} and Π_{i1t} are price indices (Anderson and van Wincoop, 2003):

- p_{n1t} is the inward multilateral resistance
- Π_{i1t} is outward multilateral resistance

The gravity equation can be used to estimate trade costs d_{in1t} from observed trade flows X_{in1t} (see for example Piermartini and Yotov, 2016) Derivation

Calibration

- The countries are the US, China, and rest of the world (ROW)
- Manufacturing and agriculture goods are assumed to be tradable while services are assumed to be nontradable
- Some parameters are the same in all three countries, while other parameters are country-specific

- The share parameters in the CES consumption function b are set to match the sectoral data for tradable goods consumption in US, China and the ROW, calculated from 2013 COMTRADE data
- Consumption shares of import goods from China and ROW in US are 6.5% and 21.2%, respectively
- For China, consumption shares of import goods from US and ROW are 1.2% and 8.5%, respectively
- For ROW, consumption shares of import goods from US and China are 3.7% and 4.3%, respectively

- Trade costs are estimated using a gravity regression using 2013 trade and output data (from IndStat and FaoStat)
- Domestic trade costs are normalized to 1
- Trade costs were estimated for about 50 countries and 30 manufacturing and agriculture industries and we calculate (trade) weighted averages

Total trade costs:

China to US	1.304
US to China	1.610
China to ROW	1.899
US to ROW	1.655
ROW to China	1.350
ROW to US	1.186

- Trade costs include tariffs and all the other trade-related costs
- We need to separate tariffs from other trade costs
- We use the MFN tariff rates: US 2.7%, China 4.0% and the ROW 4.0% (world average)
- The data are from the World Bank (weighted mean, all products)
- The data for US and China is from the year 2015 and the world average is from the year 2012

- We set the government spending endogenously to make the lump-sum transfers (taxes) at zero at the steady state
- This minimizes the income effects coming from fiscal sector when tariff rates change
- The initial asset holding positions $(p_1 B_1 / p_x y_x,\ p_2 B_2 / p_m y_m)$ for US and China are set to match the steady state trade balance at zero
- Trade balance in the data (-4.04% of GDP for US and 4.41% of GDP for China in 2016) is hard to reconcile with a steady state

Solution methodology

- We analyze how changes in tariff rates affect both steady state and transitional dynamics of the model economy
- We assume that changes in tariff rates are permanent
- Steady states are calculated by combining closed-form solutions and numerical solutions for producer prices
- In order to solve for the model dynamics, we employ a linear approximation method based on a shooting algorithm

Shooting algorithm

- Linear approximation incurs large approximation errors if the model moves away from the steady state where the approximation is performed
- In order to minimize the approximation errors, we need to approximate the model around the new steady state
- However, the value of asset holdings at the new steady state is not known because of the well-known indeterminacy issue in small open economy models with incomplete financial markets: Kim and Kose (MD, 2003), Schmidt-Grohe and Uribe (JIE, 2003)
- Shooting algorithm uses an iteration method to pin down the new steady state asset holding position that is consistent with the debt-accumulation dynamics of the existing steady state equilibrium
- These procedures are documented in Kim and Kose (JIE, 2014)

Using a shooting algorithm (Mendoza and Tesar, AER 98, etc)

- To ensure that the post-reform steady state of bond is consistent with the equilibrium solution of debt-accumulation dynamics
- First, assume that the post-reform steady state value of B is equal to initial B and linearize the model around the post-reform steady state
- Simulate the model for a sufficient time period (to make sure that the model converged to the new steady state, 1,000 periods in this paper), and calculate the last period B consistent with the debt-accumulation dynamics
- Update the post-reform steady state B with this new B and repeat the loop until B converges to a fixed point

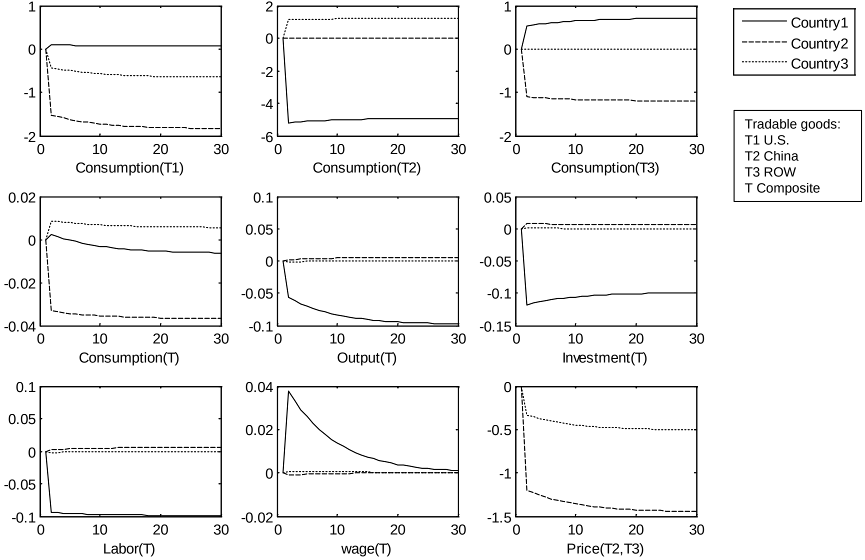
Simulations

- Model is calibrated for the US, China, and the rest of the world (ROW)
- We analyze the effects of an increase in US tariff on
  - (a) Chinese goods
  - (b) both Chinese and ROW goods
- For each of the above, we consider two possibilities:
  - (1) No retaliation
  - (2) Symmetric retaliation
- We also do
  - (∗) 1(a) and 1(b) with higher trade elasticity
  - (∗) 1(a) and 1(b) with higher tariff rates

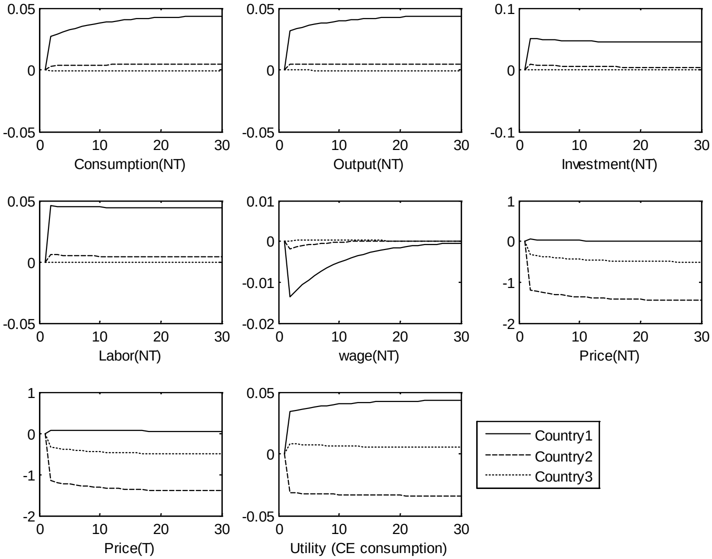
Increase in U.S. tariffs on Chinese goods to 10%

- In the steady state, the tariff rate imposed by US on Chinese goods are at 2.7%
- We increase this tariff rate from 2.7% to 10% and analyze how the model economy responds
- US tariff rate against import goods from ROW remains the same
- There is no retaliation by other countries
- Policy change is expected to be permanent (no WTO challenge)

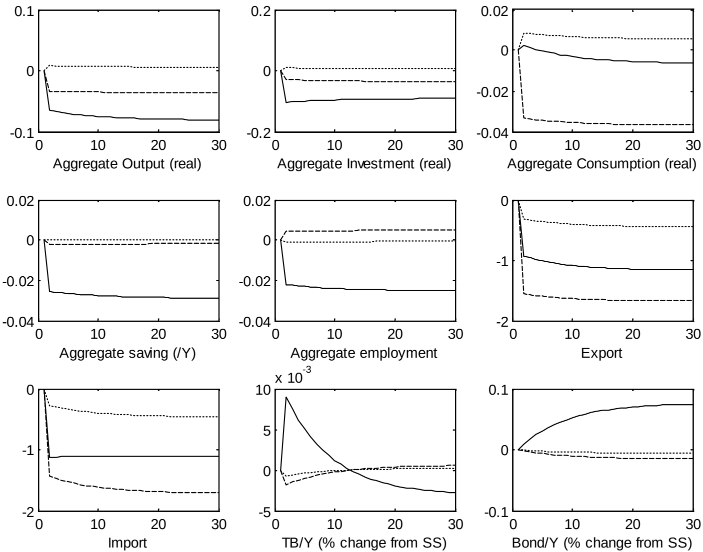
Impulse responses to an increase in US tariff rate against Chinese import goods to 10%



Impulse responses to an increase in US tariff rate against Chinese import goods to 10%



Impulse responses to an increase in US tariff rate against Chinese import goods to 10%



Summary of results

Modeling results show that

- US imports from China fall and US imports from the ROW increase
- US wage in the tradable goods sector increases temporarily but then returns to its original level
- US exports fall because of an increase in US producer price
- US trade balance improves in the short run, but then decreases to below its initial level after about 13 years
- Due to the temporary improvement in US trade balance, US accumulates foreign assets
- Both savings and investment fall in the US, but the initial fall in investment is greater than the fall in savings

Changes in consumption side

- US consumption of Chinese import goods drops by 4.9%
- US consumption of ROW import goods increases by 0.7%–trade diversion effect
- US consumption of US produced good increases by 0.06%
- US consumption of nontraded good increases by 0.04%
- Overall US tradable good consumption slightly drops by 0.007%
- Consumption of US-produced good in China and ROW decreases by 1.84% and 0.65%
- This is due to a relative increase in US good's producer price

Changes in production side

- US tradable good production decreases by 0.1%
- Lower demand for US export goods due to an increase in its relative price
- US nontradable good production increases by 0.05%
- Labor supply shifts from tradable to nontrdable sector: Wage in the tradable sector temporarily increases

Changes in aggregate variables

- Import decreases by 1.1% in the long run
- Export decreases by 1.17% in the long run: trade balance deficit (0.003% of GDP)
- Transitional dynamics: trade balance improves temporarily for the first 13 years (peak at 0.008% of GDP)
- Initial decrease in investment (0.1%) is larger than that in saving (0.07%): trade balance surplus
- Positive bond holdings (0.08% of GDP) in the long run

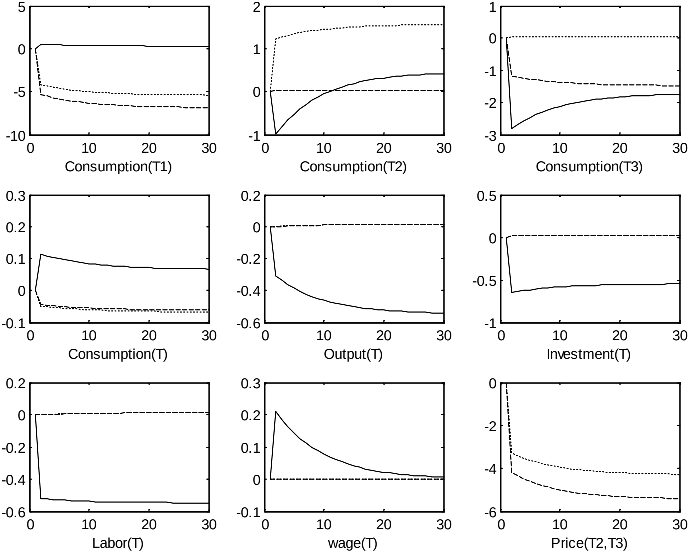
Long run changes of variables (increase of US tariff rate against Chinese import goods to 10%)
(percentage change from the steady state)

	Country 1	Country 2	Country 3
c1	0.0583	-1.8401	-0.6533
c2	-4.9269	0.0155	1.2248
c3	0.7136	-1.1972	-0.0026
C1	-0.0066	-0.0369	0.0054
y1	-0.0988	0.006	-0.0003
i1	-0.0988	0.006	-0.0003
h1	-0.0988	0.006	-0.0003
w1	0	0	0
P1	0.0506	-1.4099	-0.5141
c2	0.044	0.004	-0.0009
y2	0.0439	0.004	-0.0008
i2	0.0439	0.004	-0.0008
h2	0.0439	0.004	-0.0008
w2	0	0	0
p2	0	-1.4502	-0.5079
p11,p21,p31	0	-0.0145	-0.0051
Aggregate Output	-0.0306	-1.4452	-0.5084
Aggregate Consumption	0.044	-1.4462	-0.5087
Aggregate Investment	-0.0407	-1.445	-0.5084
Aggregate Labor	-0.0251	0.005	-0.0006
Export	-1.169	-1.6738	-0.4518
Import	-1.1055	-1.7151	-0.4666
Trade balance (/Y)	-0.003	0.0006	0.0002
Bond (/Y)	0.076	-0.0153	-0.0055
Conditional gains	0.0394	-0.0321	0.0056
Unconditional gains	0.0433	-0.0343	0.0048
Transitional gains	-0.0039	0.0023	0.0008

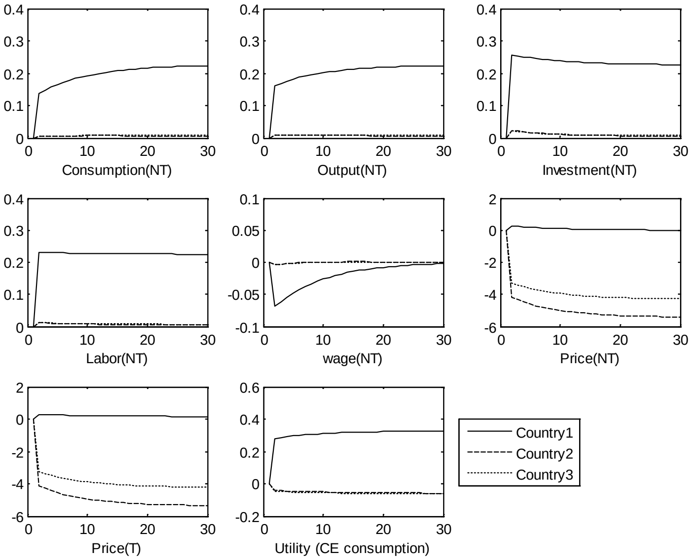
Increase in tariff rates against all import goods

- We increase U.S. tariff rates on Chinese and ROW goods to 10% and analyze how the model economy responds
- There is no retaliation by other countries
- Policy change is expected to be permanent

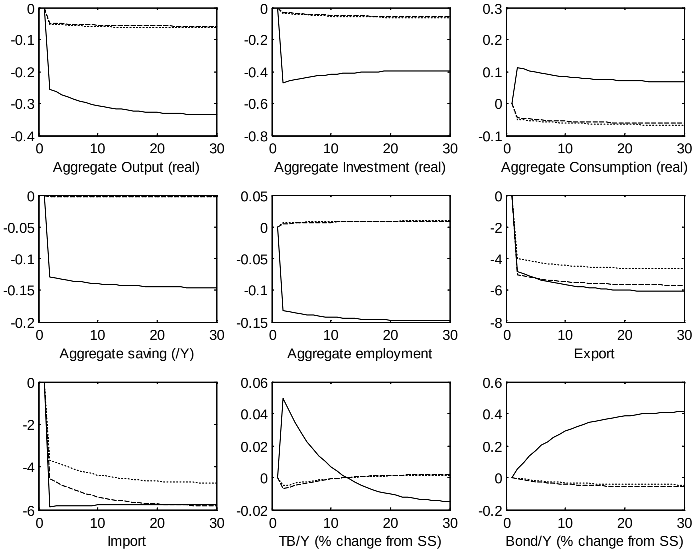
Impulse responses to an increase in US tariff rate against all import goods to 10%



Impulse responses to an increase in US tariff rate against all import goods to 10%



Impulse responses to an increase in US tariff rate against all import goods to 10%



Main changes

- Import from both China and ROW initially decrease. More negative response in imports from ROW.
- Consumption on US good increases by 0.27%; much more than the previous case (0.07%)
- Overall US tradable good consumption increases by 0.07%
- Similar response in production sector (larger scale)
- Consumption on US produced good in China and ROW decreases by 6.9% and 5.5%
- Export decreases by 6.1%, import decreases by 5.8% in the long run
- Trade balance initially increases by 0.05% of GDP, stays in surplus for 13 years, then decreases to deficit of 0.02% in the long run

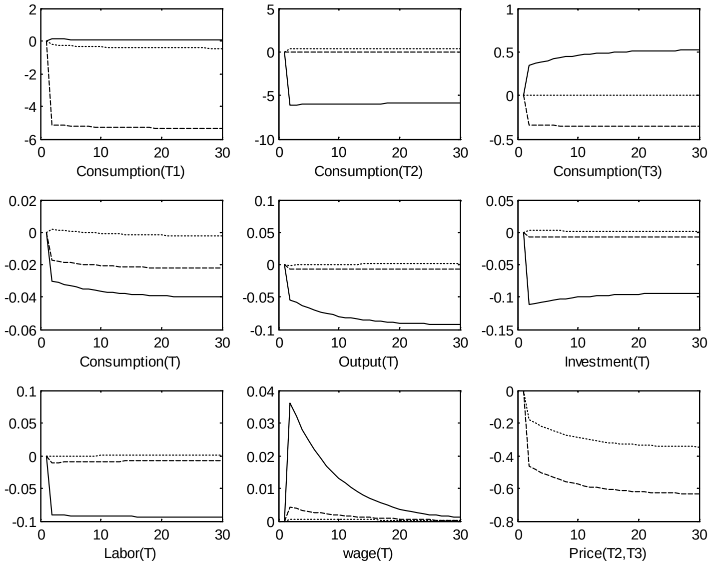
Long run changes of variables (increase of US tariff rate against all import goods to 10%)
(percentage change from the steady state)

	Country 1	Country 2	Country 3
c1	0.2709	-6.8945	-5.4631
c2	0.4568	0.0249	1.5627
c3	-1.7264	-1.4867	0.0279
C1	0.0659	-0.0625	-0.068
y1	-0.5474	0.0128	0.0124
i1	-0.5474	0.0128	0.0124
h1	-0.5474	0.0128	0.0124
w1	0	0	0
P1	0.1598	-5.3735	-4.2366
c2	0.2258	0.0057	0.0068
y2	0.2251	0.0057	0.0068
i2	0.2251	0.0057	0.0068
h2	0.2251	0.0057	0.0068
w2	0	0	0
p2	0	-5.4381	-4.3082
p11,p21,p31	0	-0.0544	-0.0431
Aggregate Output	-0.1781	-5.4292	-4.2989
Aggregate Consumption	0.2258	-5.4327	-4.3017
Aggregate Investment	-0.2329	-5.4287	-4.2985
Aggregate Labor	-0.1484	0.0091	0.0095
Export	-6.1232	-5.706	-4.6555
Import	-5.7685	-5.8638	-4.7793
Trade balance (/Y)	-0.017	0.0023	0.0018
Bond (/Y)	0.4252	-0.0584	-0.046
Conditional gains	0.3022	-0.0516	-0.0564
Unconditional gains	0.3271	-0.0595	-0.0641
Transitional gains	-0.0249	0.0079	0.0077

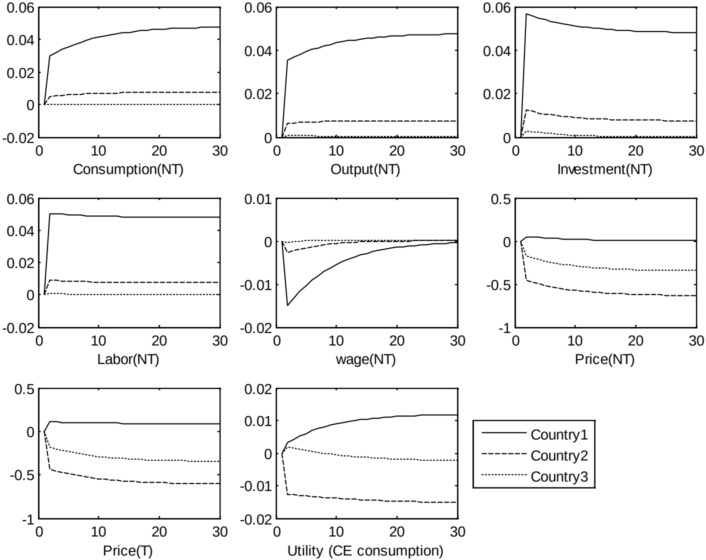
Increase in U.S. tariff rates on China to 10%, With retaliation

- We increase U.S. tariff rates on Chinese goods to 10%
- We increase China's tariffs on U.S. goods also to 10%
- Policy change is expected to be permanent

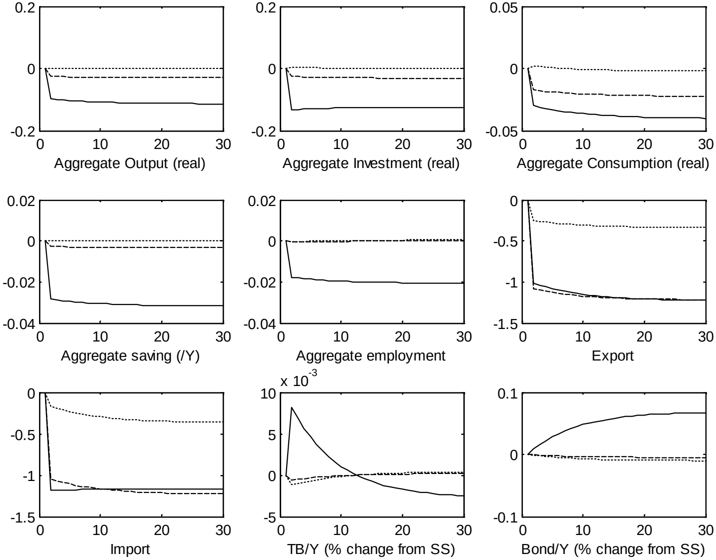
Impulse responses to an increase in US tariff rate against Chinese goods to 10%, with retaliation



Impulse responses to an increase in US tariff rate against Chinese goods to 10%, with retaliation



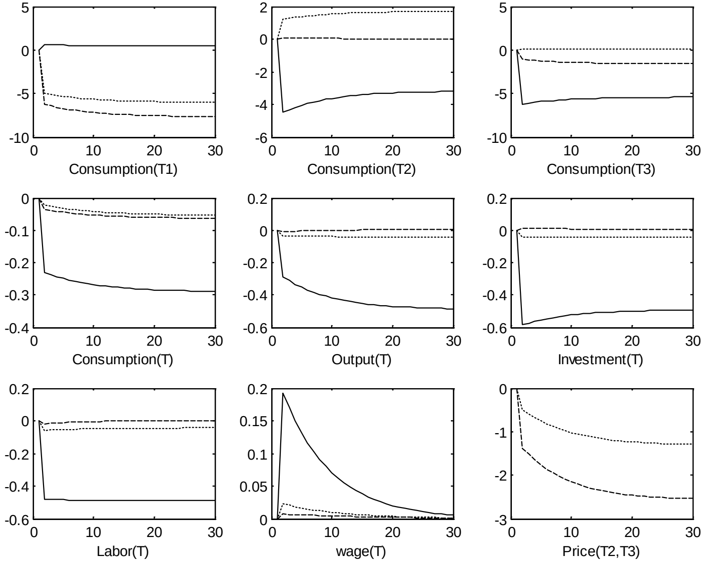
Impulse responses to an increase in US tariff rate against Chinese goods to 10%, with retaliation



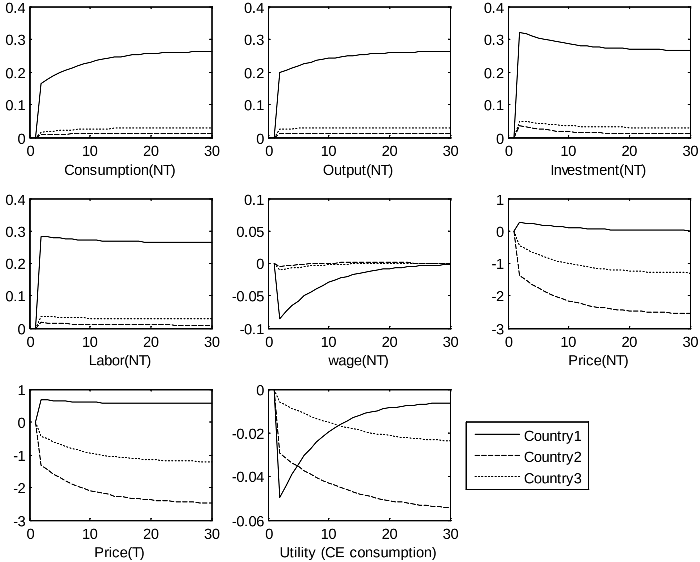
Increase in U.S. tariff rates on China and ROW to 10%, With retaliation

- We increase U.S. tariff rates on Chinese and ROW goods to 10%
- We increase China's and ROW's tariffs on U.S. goods also to 10%
- Policy change is expected to be permanent

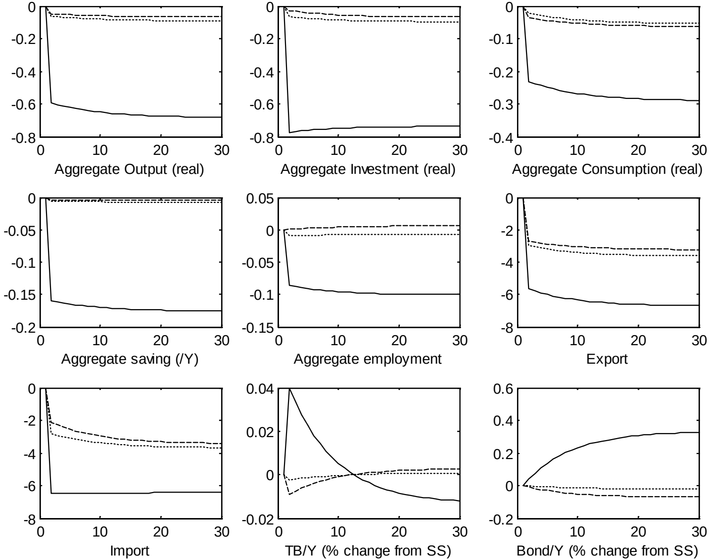
Impulse responses to an increase in US tariff rate against Chinese and ROW goods to 10%, with retaliation



Impulse responses to an increase in US tariff rate against Chinese and ROW goods to 10%, with retaliation



Impulse responses to an increase in US tariff rate against Chinese and ROW goods to 10%, with retaliation



Summary of welfare effects

Percentage change in welfare from the steady state

	U.S.	China	ROW
Tariff on China, no retaliation			
Conditional gains	0.0394	-0.0321	0.0056
Unconditional gains	0.0433	-0.0343	0.0048
Transitional gains	-0.0039	0.0023	0.0008
With Chinese retaliation			
Conditional gains	0.0094	-0.0138	-0.0012
Unconditional gains	0.0119	-0.0154	-0.0026
Transitional gains	-0.0025	0.0016	0.0015
Tariffs on all, no retaliation			
Conditional gains	0.3022	-0.0516	-0.0564
Unconditional gains	0.3271	-0.0595	-0.0641
Transitional gains	-0.0249	0.0079	0.0077
With retaliation			
Conditional gains	-0.0154	-0.0455	-0.018
Unconditional gains	-0.006	-0.0561	-0.0254
Transitional gains	-0.0093	0.0106	0.0075

Increase in U.S. tariff rates to 10%
With higher trade elasticity

- We study the effects of higher trade elasticity by repeating the first two counterfactuals with higher trade elasticities
  - (a) We increase U.S. tariff rate on Chinese good to 10%
  - (b) We increase U.S. tariff rates on Chinese and ROW goods to 10%
- We set the trade elasticity parameter γ to 0.5
- Which increases the trade elasticity from 1.3 to 2
- There is no retaliation
- Policy change is expected to be permanent

▸ Figures

Increase in U.S. tariff rates to 25%

- We study the effects of higher tariffs by repeating the first two counterfactuals with higher tariff rates
  - (a) We increase U.S. tariff rate on Chinese good to 25%
  - (b) We increase U.S. tariff rates on Chinese and ROW goods to 25%
- There is no retaliation
- Policy change is expected to be permanent

Figures

Conclusion

- In this paper, we seek to reconcile two different modeling worlds: one of trade models focused on inter-sectoral allocation of resources and one of macro models focused on intertemporal allocation of resources.
- We develop a three country dynamic general equilibrium model with tradable and nontradable sectors in each country and incomplete asset markets with bond trading.
- The model generates optimal solutions for saving, investment and bond holdings, which are assumed to be exogenously given in many trade models.
- We calibrate the model to US, China and the ROW and analyze how an increase in US tariff rate against import goods from China and/or ROW and possible retaliation affect the three countries.

General observations from various simulation exercises:

- An increase in tariff rate decreases consumption of import goods and increases consumption of domestically produced goods
- Trade diversion effects are observed in some cases where the tariff rate is asymmetrically imposed
- There is a shift of resources in US from tradable to nontradable sector and the production of nontradable good increases
- Trade balance improves in the short run (up to around year 13), but turns into slight deficit in the long run
- Magnitude of trade balance improvement is not large
- Trade balance improvement is greater when tariffs are increased on more partners, magnitude of new tariffs is greater, and there is no retaliation
- Due to the temporary improvement in US trade balance, US accumulates foreign assets
- Both savings and investment fall in the US, but the initial fall in investment is greater than the fall in savings

Gravity derivation

We define

$$X_{injt} = c_{injt} p_{injt} = c_{injt} p_{ijt} d_{injt}$$

as total spending by country n on industry j good produced in country i

Now, focusing only on the tradable sector, we define X_{n1t} as the spending on tradable composite consumption good in country n:

$$X_{n1t} = P_{n1t} C_{n1t} = \sum_i X_{in1t} = \sum_i c_{in1t} p_{i1t} d_{in1t}$$

We derive the demand for each consumption good in sector 1 and the price of the tradable composite consumption good:

$$\begin{aligned} X_{in1t} &= b_{in}^{\frac{1}{\gamma}} \left(\frac{p_{i1t} d_{in1t}}{P_{n1t}} \right)^{\frac{\gamma-1}{\gamma}} X_{n1t} \\ P_{n1t} &= \left[\sum_i b_{in}^{\frac{1}{\gamma}} \left(p_{i1t} d_{in1t} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}} \end{aligned}$$

Using the demand equation we rewrite the market clearing condition in the tradable sector:

$$
\begin{aligned}
Y_{i1t} &= \sum_n X_{in1t} + I_{i1t} = \\
&= \sum_n \left[b_{in}^{\frac{1}{\gamma}} \left(\frac{p_{i1t} d_{in1t}}{p_{nt}} \right)^{\frac{\gamma-1}{\gamma}} X_{n1t} \right] + I_{i1t} = \\
&= b_{in}^{\frac{1}{\gamma}} p_{i1t}^{\frac{\gamma-1}{\gamma}} \sum_n \left[\left(\frac{d_{in1t}}{p_{nt}} \right)^{\frac{\gamma-1}{\gamma}} X_{n1t} \right] + I_{i1t}
\end{aligned}
$$

Rearranging, we obtain

$$
b_{in}^{\frac{1}{\gamma}} p_{i1t}^{\frac{\gamma-1}{\gamma}} = \frac{Y_{i1t} - I_{i1t}}{\sum_n \left(\frac{d_{in1t}}{p_{nt}} \right)^{\frac{\gamma-1}{\gamma}} X_{n1t}}
$$

Dividing both numerator and denominator by $Y_{1t} = \sum_i Y_{i1t}$, and defining

$$\Pi_{i1t}^{\frac{\gamma-1}{\gamma}} \equiv \sum_n \left(\frac{d_{in1t}}{p_{nt}} \right)^{\frac{\gamma-1}{\gamma}} \frac{X_{n1t}}{Y_{1t}}$$

we obtain

$$b_{in}^{\frac{1}{\gamma}} p_{i1t}^{\frac{\gamma-1}{\gamma}} = \frac{\left(Y_{i1t} - I_{i1t}\right) / Y_{1t}}{\Pi_{i1t}^{\frac{\gamma-1}{\gamma}}}$$

Using the previous equation, the demand equation for tradable good can be rewritten as

$$X_{in1t} = b_{in}^{\frac{1}{\gamma}} p_{i1t}^{\frac{\gamma-1}{\gamma}} \left(\frac{d_{in1t}}{p_{nt}}\right)^{\frac{\gamma-1}{\gamma}} X_{n1t}$$

$$= \frac{\left(Y_{i1t} - I_{i1t}\right) X_{n1t}}{Y_{1t}} \left(\frac{d_{in1t}}{p_{nt}\Pi_{i1t}}\right)^{\frac{\gamma-1}{\gamma}}$$

and the price index can be rewritten as

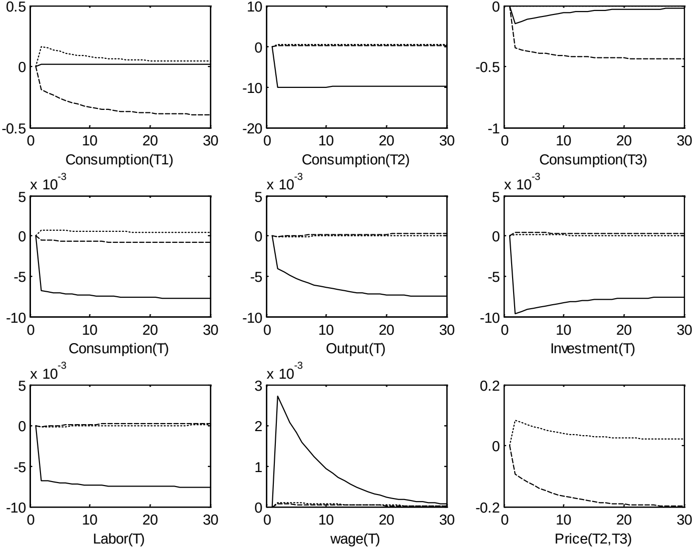
$$p_{n1t}^{\frac{\gamma-1}{\gamma}} = \sum_{i} \left(\frac{d_{in1t}}{\Pi_{i1t}}\right)^{\frac{\gamma-1}{\gamma}} \frac{\left(Y_{i1t} - I_{i1t}\right)}{Y_{1t}}$$

Back

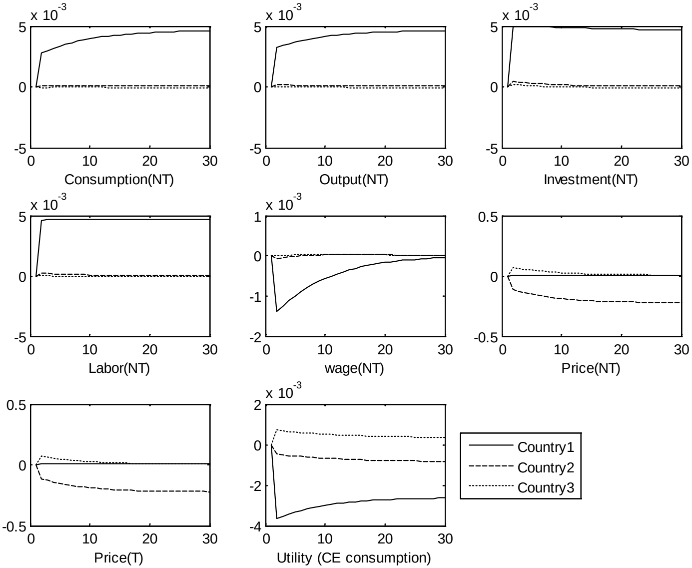
Appendix: Simulation results with higher trade elasticity

- We repeat simulations 1(a) and 1(b)
- Setting the trade elasticity parameter γ to 0.5 (increase the elasticity from 1.3 to 2)
- There is no retaliation

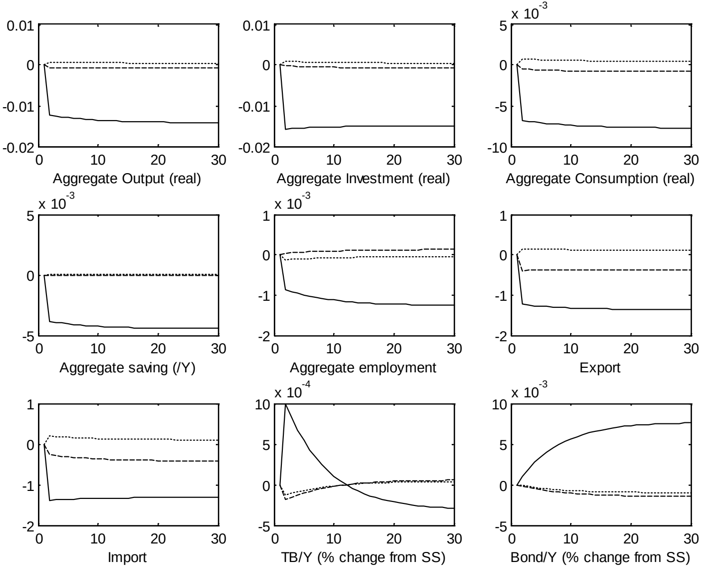
Impulse responses of an increase in US tariff rate against Chinese import goods to 10%
When $\gamma = 0.5$ (high elasticity of substitution in tradable good consumption)



Impulse responses of an increase in US tariff rate against Chinese import goods to 10%
When $\gamma = 0.5$ (high elasticity of substitution in tradable good consumption)



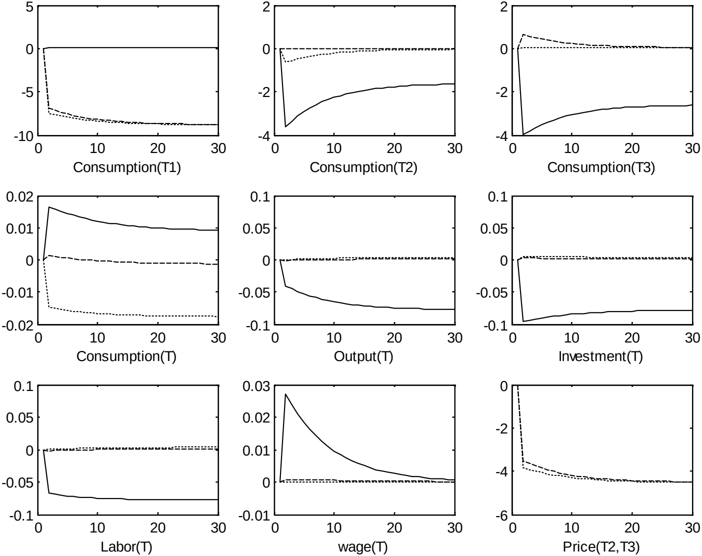
Impulse responses of an increase in US tariff rate against Chinese import goods to 10%
When $\gamma = 0.5$ (high elasticity of substitution in tradable good consumption)



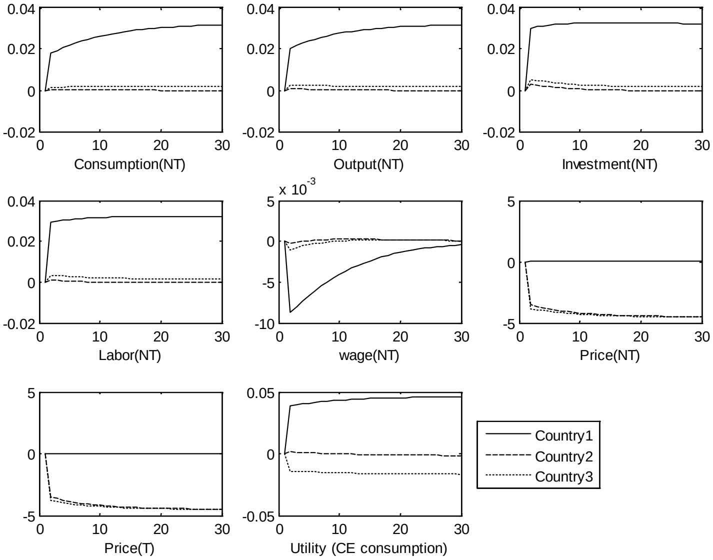
Long run changes of variables (increase of US tariff rate against Chinese import goods to 10%)
When $\gamma = 0.5$ (high elasticity of substitution in tradable good consumption)
(percentage change from the steady state)

	Country 1	Country 2	Country 3
c1	0.0172	-0.3979	0.0403
c2	-9.9472	0.0009	0.4409
c3	-0.0238	-0.4386	-0.0006
C1	-0.0078	-0.0008	0.0004
y1	-0.0076	0.0002	0
i1	-0.0076	0.0002	0
h1	-0.0076	0.0002	0
w1	0	0	0
P1	0.0125	-0.1987	0.0199
c2	0.0047	0	-0.0001
y2	0.0047	0	-0.0001
i2	0.0047	0	-0.0001
h2	0.0047	0	-0.0001
w2	0	0	0
p2	0	-0.1996	0.0205
p11,p21,p31	0	-0.0022	0.0001
Aggregate Output	-0.0017	-0.1995	0.0204
Aggregate Consumption	0.0047	-0.1996	0.0204
Aggregate Investment	-0.0026	-0.1995	0.0204
Aggregate Labor	-0.0013	0.0001	0
Export	-1.3611	-0.3765	0.1208
Import	-1.3155	-0.4168	0.1036
Trade balance (/Y)	-0.0003	0.0001	0
Bond (/Y)	0.0077	-0.0015	-0.001
Conditional gains	-0.0028	-0.0007	0.0004
Unconditional gains	-0.0026	-0.0008	0.0003
Transitional gains	-0.0001	0.0001	0.0001

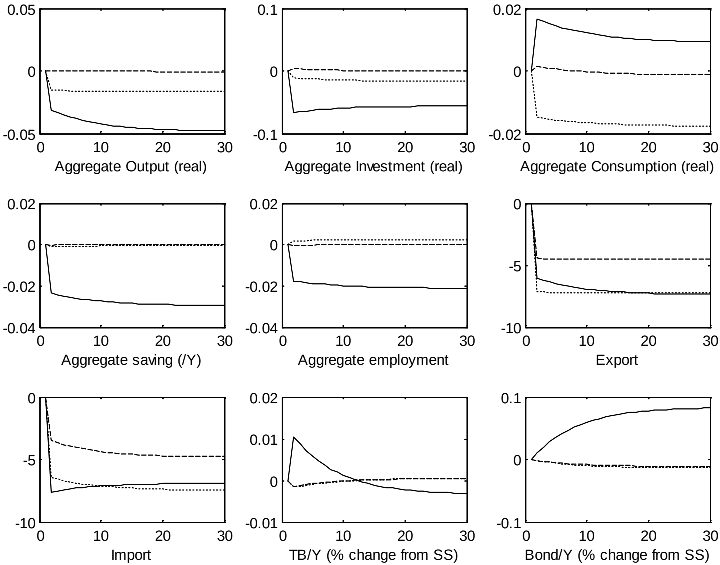
Impulse responses of an increase in US tariff rate against all import goods to 10%
When $\gamma = 0.5$ (high elasticity of substitution in tradable good consumption)



Impulse responses of an increase in US tariff rate against all import goods to 10%
When $\gamma = 0.5$ (high elasticity of substitution in tradable good consumption)



Impulse responses of an increase in US tariff rate against all import goods to 10%
When $\gamma = 0.5$ (high elasticity of substitution in tradable good consumption)



Long run changes of variables (increase of US tariff rate against all import goods to 10%)
When $\gamma = 0.5$ (high elasticity of substitution in tradable good consumption)
(percentage change from the steady state)

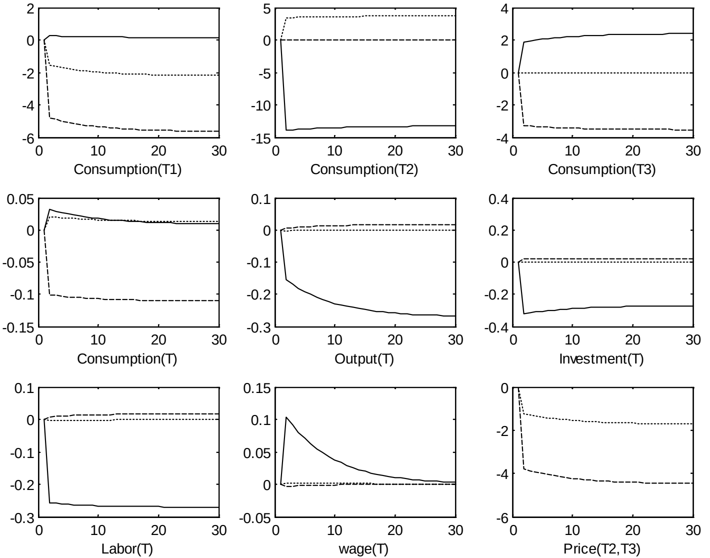
	Country 1	Country 2	Country 3
c1	0.0556	-8.7985	-8.8237
c2	-1.6146	0.001	-0.0267
c3	-2.5979	0.0487	0.021
C1	0.0089	-0.0014	-0.0178
y1	-0.0778	0.001	0.0036
i1	-0.0778	0.001	0.0036
h1	-0.0778	0.001	0.0036
w1	0	0	0
P1	0.0233	-4.4999	-4.5053
c2	0.0322	-0.0002	0.0016
y2	0.0322	-0.0002	0.0016
i2	0.0322	-0.0002	0.0016
h2	0.0322	-0.0002	0.0016
w2	0	0	0
p2	0	-4.501	-4.5238
p11,p21,p31	0	-0.045	-0.0452
Aggregate Output	-0.0254	-4.5006	-4.5212
Aggregate Consumption	0.0322	-4.5012	-4.5222
Aggregate Investment	-0.0331	-4.5005	-4.5211
Aggregate Labor	-0.0211	0.0004	0.0026
Export	-7.3747	-4.4821	-7.2271
Import	-6.8795	-4.7812	-7.4654
Trade balance (/Y)	-0.0033	0.0004	0.0005
Bond (/Y)	0.0834	-0.0108	-0.0136
Conditional gains	0.0424	-0.0006	-0.0153
Unconditional gains	0.0462	-0.0017	-0.0169
Transitional gains	-0.0038	0.0011	0.0016

Back

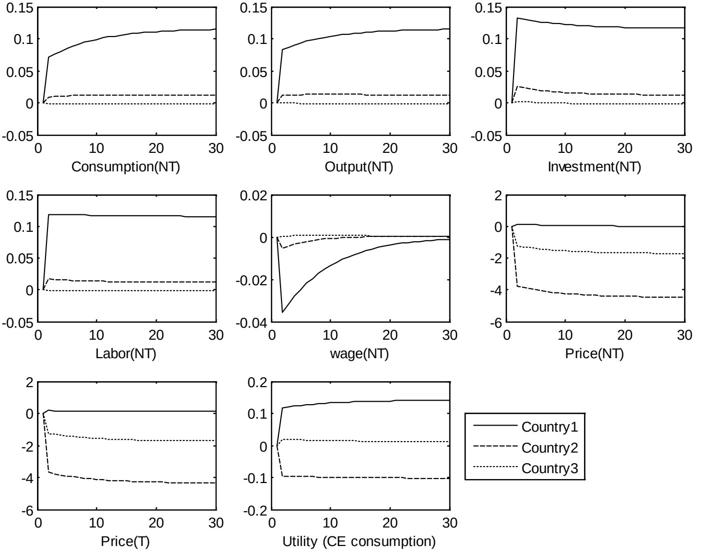
Appendix: Simulation results with higher tariffs

- We repeat simulations 1(a) and 1(b)
- Increasing the tariff rates to 25% instead of 10%
- There is no retaliation

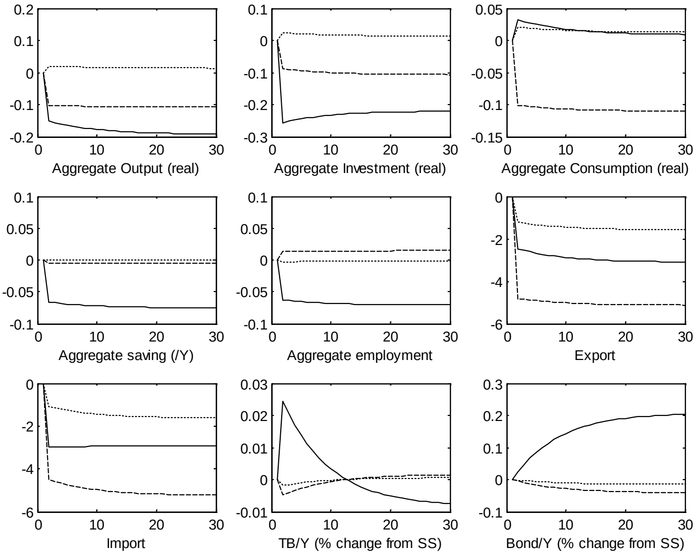
Impulse responses to an increase in US tariff rate against Chinese import goods to 25%



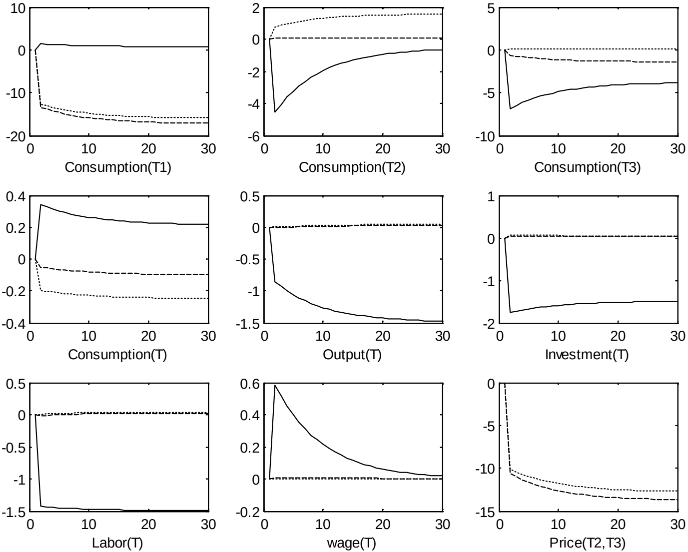
Impulse responses to an increase in US tariff rate against Chinese import goods to 25%



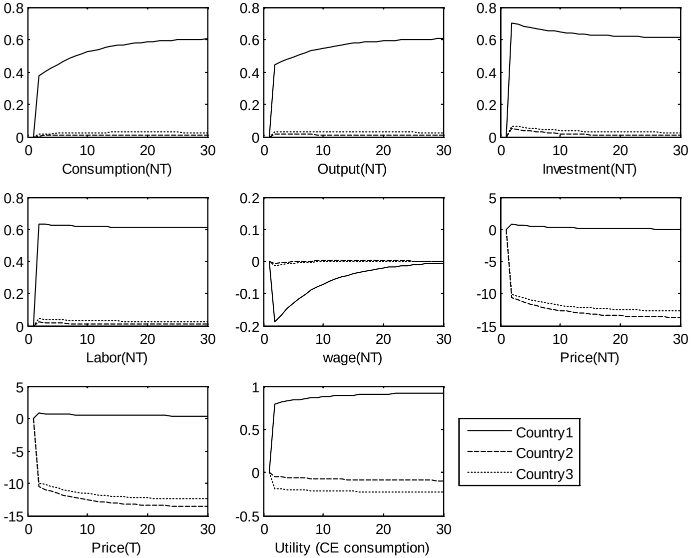
Impulse responses to an increase in US tariff rate against Chinese import goods to 25%



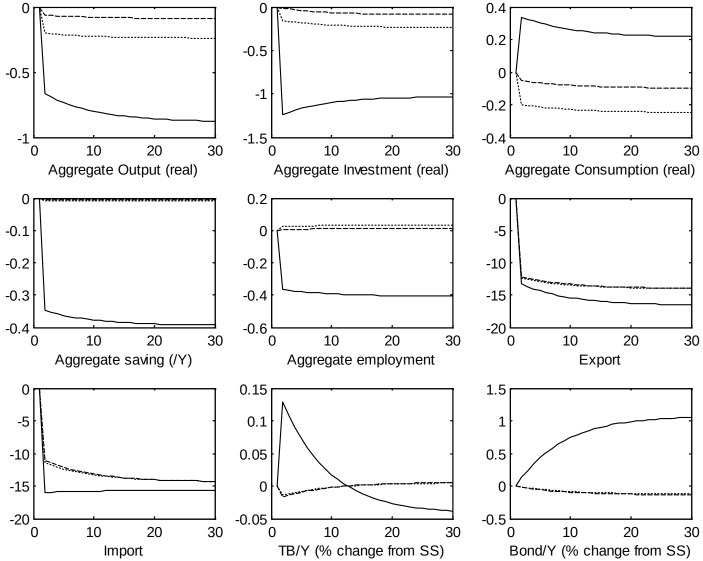
Impulse responses to an increase in US tariff rate against all import goods to 25%



Impulse responses to an increase in US tariff rate against all import goods to 25%



Impulse responses to an increase in US tariff rate against all import goods to 25%



Back