Measuring the Macroeconomic Impact of Tariffs on Steel and Aluminum: The Costs of Trade War

by

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Acknowledgments

Abstract

This paper analyzes the effects of increase of the US import tariff rates of Steel & Aluminum and the costs of trade war, when China increases tariff on imports from the US in response. The study uses New Keynesian open-economy framework, featuring nominal rigidities in prices, flexible exchange regime and introduction of multiple sectors in the economy. The tariffs are added in the model to assess the effects of tariff shocks in the economy. The model closely follows the methodology used in Linde and Pescatori (2017) and Erceg et al. (2017), but deviates from the symmetry assumption, and adds sectors in the economy to see the effects of trade war when applied only on one specific sector. For the analysis, I use cross-country data on GDP, terms of trade, and tariffs available at the World Trade Organization and World Bank. As a result, the unilateral increase in tariff rate on the sector of A&S decreases the US GDP, labor and nominal wages. China's retaliation worsens the effects on terms of trade and GDP. Trade war substantially offsets the real appreciation of the dollar.

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Chapter 1

Introduction

This paper analyzes the effects of the increase in the US import tariff rates of Aluminum & Steel (A&S) and the costs of trade war, in case when China increases tariff on imports from the US in response. For decades, the US was successfully moving toward open trade regime, but recently, US president signed proclamation imposing 25 percent penalty on steel and 10 percent on aluminum imports coming from the EU and China. The continued statements provoked reactions resembling start of the trade war. As the threat of trade war continues, the US made a verbal statement to impose tariffs as high as 25% on all imports from China, in case if China decides to retaliate.

On the literature, there is not much research done on the effect of tariff shocks on the macroeconomic indicators, as the majority of the research are focusing outside the macroeconomic sphere. To explore these effects, I use the New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model. I put assumptions on firm-pricing behavior, exchange-rate determination mechanism, asset market and specify the monetary rule to make it close to the economy features of the US and China. In modeling, I closely follow the methodology used in Gali and Monacelli (2005), Monacelli (2005), Santacreu (2005), Linde and

Pescatori (2017) and Erceg et al. (2017). At first I will increase in tariff from US side to explore the effects of unilateral tariff shock to the US economy. Then the effects of the bilateral tariff shock is studied. As a result, both China and the US lose in terms of GDP, and terms of trade. The trade war scenario turn out to worsen the situation over the GDP, employment and wages, but slightly softens the inflation in the US overall, after the adjustment of relative prices.

The thesis is organized as follows. In chapter 2 a short Literature Review is given on a topic. Chapter 3 introduces the Model. Chapter 4 summarizes the results. Chapter 5 concludes.

1.1 Literature Review

With the proposed recent changes in the US trade policies there is a growing literature on the macroeconomic effects of increase in import and export tariffs, with the stress on the destination-based-cash-flow taxes or its VAT-payroll subsidy equivalents (Auerbach et al., 2017) and the Border Adjustment Taxes (BAT) (Erceg et al., 2017). In their calibration Linde and Pescatori (2017), quantitatively assessed the costs of the trade wars. According to them if the US and the rest of the world (ROW) bilaterally increase their import tariffs by 10 percent both will experience 1 percent fall in trade and 0.5 percent fall in GDP. They also, documented that in the short-term the real exchange rate does not adjust immediately, because of gradually adjustment of nominal exchange rate. In the recent report submitted by ImpactECON, LLC (2018) it is projected that if all projected sanctions on tariff take place it will result more than 2.75 million more unemployed workers in US, as firms will decrease production levels and lay off workers.

Chapter 2

The Theoretical Model

In this chapter I present two-country New Keynesian DSGE model closely following methodology in Gali and Monacelli (2005), Monacelli (2005), Santacreu (2005), Linde and Pescatori (2017) and Erceg et al. (2017). I put assumptions on how firms determine the prices of imported goods, on how the exchange rate is determined, and on the monetary policy rule to make it as close to the economy features of the US and China as possible. First, I develop two-country NK-DSGE model that captures the basic structure of US and China. Second, I separate two sectors in both countries, having in mind one for Aluminium and Steel (A&S) and the other for the rest of the products. Third, I introduce import and export tariffs for each of the sections separately, to be able to assess the effects of shocks on tariffs of A&S sector. In this section, all the variables with asterisk ('*') used to describe the foreign economy.

2.1 Firms

I consider continuum of monopolistically competitive firms each using constant-elasticity of substitution (CES) technology to produce goods. There are continuum of differentiated intermediate goods ($i \in [0;1]$), each of them produced by a firm. Every firm produces goods both for domestic market and for the foreign market. I denote the demand for good i in domestic market by $Y_{Dt}(i)$, then the aggregate demand by Y_{Dt}, would be:

$$Y_{Dt}(i) = \Big[\frac{P_{Dt}(i)}{P_{Dt}}\Big]^{\frac{-(1+\theta_p)}{\theta_p}} Y_{Dt} \tag{2.1}$$

where P_{Dt} is an aggregate price index which will be defined later. θ_p is the elasticity of substitution between goods i and j. There are two sectors in the economy for production. Assume that sector 1 represents the sector of A&S and sector 2 is for the rest of the products. The each domestic firm's foreign demand for goods in sector 1 and goods in sector 2 would be M^*_{1t} and M^*_{2t} similarly, hence a firm i will produce:

$$X_{1t}(i) = \Big[\frac{P^*_{M1t}(i)}{P^*_{M1t}}\Big]^{\frac{-(1+\theta_p)}{\theta_p}} M^*_{1t} \tag{2.2}$$

$$X_{2t}(i) = \Big[\frac{P^*_{M2t}(i)}{P^*_{M2t}}\Big]^{\frac{-(1+\theta_p)}{\theta_p}} M^*_{2t} \tag{2.3}$$

where $X_{1t}(i)$ and $X_{2t}(i)$ are the quantities that each domestic goods demanded in foreign economy, and , $P^*_{M1t}(i)$ and $P^*_{M2t}(i)$ are the prices that the domestic firm charges for each of the products in foreign economy, while P^*_{M1t} and P^*_{M2t} are the aggregated prices that firm i charges foreign economy for goods in sector 1 and sector 2. Similarly, M^*_{1t} and M^*_{2t} would be the aggregate of foreign economy's demand for goods in sector 1 and sector 2.

A firm I uses the following production function to produce $Y_t(i)$ amount of good i for both sectors:

$$Y_t(i) = \left[\omega_K^{\frac{\rho}{1+\rho}} K_t(i)^{\frac{1}{1+\rho}} + \omega_L^{\frac{\rho}{1+\rho}} (Z_t L_t(1i))_K^{\frac{1}{1+\rho}}\right]^{1+\rho} \tag{2.4}$$

For the production of $Y_t(i)$, producer uses capital $K_t(i)$ and labor $L_t(i)$. There is a perfect factor mobility between both sectors. Because of the mobility, the wages and return to capital is identical in both sectors, therefore there is no reason to separate the factors between different sectors of production and write two separate production functions (unless one decides to set a different production function for sector 1 and sector 2). Therefore, producer first produces all continuum of goods i using the same technology, labor, and capital. Then aggregates all products in two sectors and exports to foreign country. The aggregation of goods in sector 1 and sector 2 is necessary for the export, as the goods in sector 1 (A&S) face different tariff rates than the goods in sector 2. The country specific shock is denoted by Z_t. Also, it is assumed that there is a perfect competition in factor markets, hence firms take the rental price of capital (R_{Kt}) and wages (W_t) as given. Firms are allowed to adjust either factor of production without any cost. Th technology shock follows an AR(1) process, which in log-linearized form would be:

$$z_t = \rho_z z_{t-1} + \epsilon_{z,t} \tag{2.5}$$

To determine the prices of intermediate goods, Calvo-style staggered contracts (see Calvo, j1983) are used. The idea is that every firm faces a probability of $1 - \xi_p$ of changing their prices ($P_{Dt}(i)$) at time t, and ξ_p probability to leave the prices the same. These probabilities are constant over time time and is the same for each domestic firm. In case if firm decides not to optimize the prices at period t, I assume that it will reset the price as a combination of steady-state inflation and the price it has last period (Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003)):

$$P_{Dt}(i) = \pi_{t-1}^{\iota}\pi^{1-\iota}P_{Dt-1}(i)) \tag{2.6}$$

The producer optimizes its price, then it should maximize:

$$\max_{P_D(i)} \exp \sum_{j=0}^{\infty} \phi_{t,t+1}\xi_p^j \Big[\prod_{h=1}^{j} \pi_{t+h-1}(P_{Dt}(i) - MC_{t+j})Y_{Dt+j}(i)\Big] \tag{2.7}$$

where exp is the conditional expectation given all the information that is available to agents at period t, $\phi_{t;t+j}$ is the state-contingent discount factor. The first-order condition for setting the contract price of good i is:

$$\exp \sum_{j=0}^{\infty} \phi_{t,t+1}\xi_p^j \Big[\frac{\prod_{h=1}^{j} \pi_{t+h-1}(i)P_{Dt}(i)}{(1+\theta_p)} - MC_{t+j}\Big]Y_{Dt+j}(i) = 0 \tag{2.8}$$

2.2 Tariffs in a Sticky Price Framework

Low of one price (LOP) under the flexible price environment generally brings:

$$P_{Mi,t} = S_t P_{Xi,t}^{*} \frac{1+\tau_{Mi,t}}{1+\tau_{Xi,t}^{*}} \tag{2.9}$$

where p_{Mit} is the price index of imported goods in sector i, S_t is the nominal exchange rate, $\tau_{Mi,t}$ is the tariff applied on goods of sector i coming from foreign economy, and $\tau_{Xi,t}^{*}$ is the export subsidy applied by foreign economy. Note that $p_{Xi,t}^{*} = p_{Di,t}^{*}$ meaning foreign export prices should coincide with domestic prices of foreign economy (monopolistic competition). Under the sticky price environment local currency pricing method (LCP) is used. It assumes that if shock hits the tariffs, the exchange rate will allow the adjustment of the import and local prices only gradually. Therefore there will be deviations from LOP.

Let's denote that deviation by Δ_t then the LCP:

$$\Delta_t = P_{Mi,t} - S_t P^*_{Xi,t} \frac{1+\tau_{Mi,t}}{1+\tau^*_{Xi,t}} \tag{2.10}$$

The exporting firm set their prices analogues to the domestic firms. The first order condition of the firm exporting goods of sector 1 would give:

$$\exp \sum_{j=0}^{\infty} \phi_{t,t+1} \xi_m^j \Big[\frac{\prod_{h=1}^{j} \pi_{t+h-1}(i) P^*_{Mi,t}(i)}{(1+\theta_p)} - MC_{t+j} \Big] M_{i,t+j}(i) = 0 \tag{2.11}$$

where $P^*_{Mi,t}$ can be derived from the definition of Δ^*_t which is the analog of (2.10) for foreign economy.

2.3 Production of the Domestic Output Index

Because the households have Dixit-Stiglitz preferences, the domestically produced continuum of goods are aggregated into one Y_{Dt} domestic output index, in the following way:

$$Y_{Dt} = \Big[\int_0^1 Y_{Dt}(i)^{\frac{1}{1+\theta_p}} di \Big]^{1+\theta_p} \tag{2.12}$$

This aggregator work in way that minimizes the cost of producing Y_{Dt} while taking into account price of each indiviual domestically produced good $P_{Dt}(i)$. Accordingly, the price of the Y_{Dt} is given by:

$$P_{Dt} = \Big[\int_0^1 P_{Dt}(i)^{\frac{-1}{\theta_p}} di \Big]^{-\theta_p} \tag{2.13}$$

Similarly, the aggregate of the foreign demand for the goods in sector 1 and Sector 2 would be:

$$M_{1t}^{*}=\Big[\int_{0}^{1}M_{1t}^{*}(i)^{\frac{1}{1+\theta_p}}di\Big]^{1+\theta_p} \tag{2.14}$$

$$M_{2t}^{*}=\Big[\int_{0}^{1}M_{2t}^{*}(i)^{\frac{1}{1+\theta_p}}di\Big]^{1+\theta_p} \tag{2.15}$$

and accordingly, each unit of M_{1t}^{*} and M_{1t}^{*} will have a price P_{1t}^{*} and P_{2t}^{*} determined below:

$$P_{M1t}^{*}=\Big[\int_{0}^{1}P_{M1t}(i)^{\frac{-1}{\theta_p}}di\Big]^{-\theta_p} \tag{2.16}$$

$$P_{M2t}^{*}=\Big[\int_{0}^{1}P_{M2t}(i)^{\frac{-1}{\theta_p}}di\Big]^{-\theta_p} \tag{2.17}$$

Once goods from sector 1 and sector 2 are exported to foreign economy, their are combined with the domestically produced goods to produce the final consumption good. The aggregated imported goods M_{Ct}^{*} are defined in a following way.

$$M_t^{*}=\Big[\omega_M^{\frac{\rho_M}{1+\rho_M}}(M_{1t}^{*})^{\frac{1}{1+\rho_M}}+(1-\omega_M)^{\frac{\rho_M}{1+\rho_M}}(\phi_{Mt}M_{2t}^{*})^{\frac{1}{1+\rho_M}}\Big]^{1+\rho_M} \tag{2.18}$$

And accordingly, the price of one unit of aggregated imported goods would be defined as:

$$P_t^{*}=\Big[\omega_M(P_{1t}^{*})^{\frac{-1}{\rho_M}}+(1-\omega_M)(P_{2t}^{*})^{\frac{-1}{\rho_M}}\Big]^{-\rho_M} \tag{2.19}$$

where ω_{Mt} again shows the relative share of goods produced in sector 1 in total exported goods, and the parameter ρ_M shows the substitability between goods in sector 1 and sector 2 in total foreign imports.

2.4 Production of Consumption and Investment Goods

The final consumption good is produced by taking the domestic and foreign imported goods according to constant return to scale (CRS) CES production function.

$$C_{At} = \left[\omega_C^{\frac{\rho_C}{1+\rho_C}} C_{Dt}^{\frac{1}{1+\rho_C}} + (1-\omega_C)^{\frac{\rho_C}{1+\rho_C}} (\phi_{Ct} M_{Ct})^{\frac{1}{1+\rho_C}}\right]^{1+\rho_C} \tag{2.20}$$

where C_{Dt} is the demand for domestically produced goods (aggregated), M_{Ct} is the demand for imported goods (aggregated), and ϕ_{Ct} reflects costs of adjusting consumption imports.

The final consumption good is used by both households and by the government. The parameter ω_C can be determined as the degree of home bias, as it roughly shows the share of domestically produced goods in final consumption. The parameter ρ_c shows the substitutabilty between home and foreign produced goods. The parameter ϕ_{Ct} is the adjustment cost, which takes the following form:

$$\phi_{Ct} = \left[1 - \frac{\phi_{M_C}}{2}\left(\frac{\frac{M_{Ct}}{C_{Dt}}}{\frac{M_{Ct-1}}{C_{Dt-1}}}\right)^2\right] \tag{2.21}$$

This specification implies that it is costly to change the imported good's proportion when producing final consumption good. Given adjustment costs, the final good is produced by using taking C_{Dt} and M_{Ct} in a way to minimize the costs of producing the aggregate consumption good:

$$\begin{aligned}&\min_{C_{Dt+k}, M_{Ct+k}} \exp_t \sum_{k=0}^{\infty} \phi_{t,t+1}(P_{Dt+k}C_{Dt+k} + P_{Mt+k}M_{Ct+k}) + \\ &P_{Ct+k}\left[C_{A,t+k} - \left(\omega_C^{\frac{\rho_C}{1+\rho_C}} C_{Dt}^{\frac{1}{1+\rho_C}} + (1-\omega_C)^{\frac{\rho_C}{1+\rho_C}} (\phi_{Ct} M_{Ct})^{\frac{1}{1+\rho_C}}\right)^{1+\rho_C}\right]\end{aligned} \tag{2.22}$$

The price of the final consumption good is P_{Ct}, which is also the consumption price index (or equivalently, as the shadow cost of producing an additional unit of the consumption good). The production of final investment goods is models in similar way.

2.5 Households and Wage Setting

The home economy is populated with continuum of household. Each household provides a labor to the intermediate production firm as described in Erceg, Henderson and Levin (2000). There is a "labor agency" that would combine all the households' labor services (meaning hours of work) just in a way as would the intermediate good producer choose. The "labor agency" (aggregate labor, L_t) demand would be equal to all intermediate firms' demand for labor. For the aggregation of labor (labor index), the Dixit-Stiglitz methodology is used.

$$L_t = \Big[\int_0^1 \zeta N_t(h)^{\frac{1}{1+\theta_w}} di \Big]^{1+\theta_w} \tag{2.23}$$

where $\theta_w > 0$ is the elasticity of substitution for labor, and $N_t(h)$ is the working hour of an individual household h. The parameter ζ i captures the size of the household, and also, determines the relative size of the economy to the foreign one. In case if $\zeta = 1$ means that home and foreign economy are equally large. Each member of households ears individual wage equal to $W_t(h)$. The "labor agency" combines all these individual wages, sells them to the intermediate good production sector, where wages are equal across sectors are firm. The aggregation of wages by "labor agency" has the following form.

$$W_t = \Big[\int_0^1 W_t(h)^{\frac{-1}{\theta_w}} di \Big]^{-\theta_w} \tag{2.24}$$

Then, accordingly the demand of "labor agency" of the household is determined as:

$$N_t = \Big[\frac{W_t(h)}{W_t} \Big]^{-\frac{1+\theta}{\theta_w}} \frac{L_t}{\zeta} \tag{2.25}$$

Additionally we assume that there are 2 types of housholds in the economy. First type is called "forward looking" households (FL) who optimize their consumption every period based on inter-temporal utility function, taking into account their consumption and investment decisions. The second type of households are called "hand-to-mouth" households (HM), who simply consume all their income. The proportion of FL households is $1-\varsigma$ and the rest is HM. FL households face the following inter-temporal utility function:

$$\max\sum_{j=0}^{\infty}\beta^j[\frac{1}{1-\sigma}(C^O_{t+j}(h)-\iota C^O_{t+j-1})^{1-\sigma}+ \frac{\chi_0 Z^(1-\sigma)_{t+j}}{1-\chi}(1-N_{t+j}(h))^{(1-\chi)}+\mu_0 F(\frac{MB_{t+j+1}(h)}{P_{Ct+j}})] \tag{2.26}$$

where $0<\beta<1$. The inter-temporal utility form largely follows the one specify in Smets and Wouters (2003, 2007). So every household maximizes its utility based on current consumption (also the aggregate consumption of the previous period for all the FL households), the leisure, and it's real money balances.

FL household solves the inter-temporal utility function based on the following budget constraint.

$$P_{Ct}C^O_t(h)+P_{It}I_t(h)+MB_{t+1}(h)-MB_t(h)+\int_s \xi_{t,t+1}B_{Dt+1}(h)- B_{Dt}(h)+P_{Bt}B_{Gt+1}(h)-B_{Gt}+S_t\frac{P^*_{Bt}B_{Ft+1}(h)}{\phi_b t}-S_tB_{Ft}(h)= W_t(h)N_t(h)+\Gamma_t(h)+R_{kt}K_t(h)+P_{It}\delta K_t(h)-P_Dt\phi_{It}(h) \tag{2.27}$$

where $(MB_{t+1}(h)-MBt(h))$ is the nominal money holdings by FL households, B_{Dt+1} is the state contingent bond. There is only one asset that can be traded cross- border and is denoted by $B_{Ft}(h)$. B_{Gt+1} and B_{Ft+1} is the government bonds that each household can issue from home and foreign economy. Bonds have a one currency unit of return that can be collected next period, and can be bought by a discount price (P_{Bt} and P^*_{Bt}) at the current period. S_t is the nominal exchange rate. In order to hold a foreign issued bond, each household should pay a transaction cost, which is captured by the parameter ϕ_{bt} and depends on the ratio of net foreign assets to GDP:

$$\phi_{bt} = exp(-\phi_b \frac{B_{Ft+1}}{P_{Dt}Y_{Dt}}) \tag{2.28}$$

The low of motion of the capital is given by:

$$K_{t+1}(h) = (1-\delta)K_t(h) + I_t(h) \tag{2.29}$$

where δ is the depreciation rate of capital.

Each member of FL household h earns labor income, $W_t(h)N_t(h)$. The household leases capital at the rental rate R_{Kt} . The household receives a depreciation write-off of $P_{It}\delta$ per unit of capital. Each member also receives an $\Gamma_t(h)$ share of the profit of all firms. Following Christiano, Eichenbaum and Evans (2005), I assume that it is costly to change the level of gross investment from the previous period, so that the acceleration in the capital stock is penalized:

$$\phi_{It}(h) = \frac{1}{2}\phi_I \frac{(I_t(h) - I_{t-1})^2}{I_{t-1}} \tag{2.30}$$

For FL I assume that nominal wages are set again with Calvo-style staggered contracts . Namely, each household optimizes it's wage with $1-\xi_w$ probabilty, and with ξ_w probability the households reset the wage according to according to:

$$W_t(h) = \omega_{t-1}^{\iota_\omega} \omega^{1-\iota_\omega} W_{t-1}(h) \tag{2.31}$$

where $\omega_{t-1} = W_t/W_{t-1}$, and $\omega = \pi$ is the steady state rate of change in the nominal wage. Finally, we consider the determination of consumption and labor supply for HM households. A typical member of a HM household simply equates their nominal consumption spending, $P_{Ct}C_t^{HM}(h)$ to their labor income:

$$P_{Ct}C_t^{HM}(h) = W_t(h)N_t(h) \tag{2.32}$$

The HM households set their wage equal to the average wage of the FL households. Since HM households face the same labor demand schedule as the FL households, this assumption implies that each HM household works the same number of hours as the average for FL households.

2.6 Monetary and Fiscal Policy

The monetary policy rate follows Taylor-type policy rule, given by :

$$i_t = (1 - \gamma_i)(\gamma_\pi \pi_{Ct} + \gamma_x x_t + \gamma_{\Delta x} \Delta x_t) + \gamma i_{t-1} \tag{2.33}$$

where π_{Ct} is consumer price inflation, and x_t is the model consistent output gap, i.e. the percent deviation of actual output from the notional level of output that would prevail if prices and wages were fully flexible.

The government revenue from collecting tariff duties and export subsidies is:

$$Tr_t = \sum_{i=1}^{2} \left[\tau_{Mi,t} \frac{P_{Mi,t}}{1+\tau_{Mi,t}} M_{it} - \tau_{Xi,t} \frac{S_t P^*_{Mi,t}}{1+\tau^*_{Mi,t}} X_{it} \right] \tag{2.34}$$

issues nominal debt B_{Gt+1} at the end of period t to finance its deficits according to:

$$P_{B,t} B_{G,t+1} - B_{G,t} = P_{C,t} G_t - (MB_{t+1} - MB_t) - Tr_t \tag{2.35}$$

2.7 Market Clearing Conditions and Resource Constraints

The final consumption is the sum of private and government consumption:

$$C_{At} = C_t + G_t \tag{2.36}$$

and the private consumption C_t is both consumption of FL and HM consumers:

$$C_t = (1-\varsigma) C_t^{FL} + \varsigma C_t^{HM} \tag{2.37}$$

Domestic goods the aggregate resource constraint is:

$$Y_{Dt} = C_{Dt} + I_{Dt} + \phi_{It} + \frac{\zeta^*}{\zeta} M_t^* \tag{2.38}$$

where ϕ_{It} is the adjustment cost on investment aggregated across all households.

Total imports is allocated between consumption and investment sector:

$$M_t = M_{Ct} + M_{It} \tag{2.39}$$

From budget constraint of FL households, consumption rule of HM households with the government budget constraint, the net foreign assets can be expressed as:

$$\frac{P^*_{B,t}B_{F,t+1}}{\phi_{bt}} = B_{F,t} + P^*_{Mt}\frac{\zeta^*}{\zeta}M^*_t - P_{Mt}M_t \tag{2.40}$$

This expression can be derived from the budget constraint of the FL households after imposing the government budget constraint, the consumption rule of the HM households, the definition of firm profits, and the condition that domestic state-contingent non-government bonds (B_{Dt+1}) are in zero net supply.

Chapter 3

Calibration and Model Parametrization

I use the data taken from World Bank (WB) and World Trade Organization(WTO) for calibration and parametrization of the model. The data for GDP is taken from WB for the year of 2017, and used to calculate the relative sizes of the economies. In the model I assume that China and US are the only countries in the world, where the US constitutes 61 percent of world GDP, and consequently China would be 39 percent (Table 3.1). Both economies are considered to be large.

Table 3.1: Import Shares

	US	**China**
Country size (GDP)	61 %	39 %
Imports / GDP	11 %	12.5 %
Imports of S&A/ Total Imports)	1 %	0.3 %

Table 3.1 presents the relative sizes of the US and China, their imports as a share of GDP and imports of A&S as a share in imports. The data for total imports and imports

of A&S are taken from WTO again for the year 2017.

Given this data, in the two-country model, I choose the country size parameter equal to 0.6, as US constitutes to 61 percent of the world economy. The import to GDP ratio is set to 0.11, and the import to GDP share for China is set to 12.5 percent, which are intend to match with their import to GDP share with the world economy. The share of imports of A&S/GDP from China to US is set 0.1 percent, and from US to China 0.05 percent, to again match the real data also presented in Table 3.1.

I take most favored nation tariffs (simple averages across products) from WTO as tariff rates between countries. The data is presented in the Table 3.2. The countries in column represent the import destination countries, while countries in rows represent importing countries.

Table 3.2: Import Tariff Rates (MFN)

	ROW	**US**	**China**
US	4.65	-	3.82
China	9.59	9.17	-

As we see from Table 3.2, the US tariff rate of 3.82 percent is relatively lower than 4.65 percent that US applies to ROW. In contrary, China has a stricter trade policy, applying on average 9.5 percent tariff rate on all imports. I incorporate this tariff rates into the model, by setting US import tariff rate equal to 3.82 and China's import tariff rate equal to 9.17.

The other calibration parameters are mainly following the ones taken from Linde and Pescatori (2017) and Bernanke, Gertler and Gilchrist (1999). The full list of the parameters, with values and descriptions is provided in the Table 6.1 in the Apppendix. Most of the parametrization is done symmetrically for both countries.

Table 3.3: Parameter values

Parameter	Parameter Description	value
β	Rate of time preference (subjective discount factor)	0.995
σ	Utility functional parameter	1
ρ_C	ES of domestic and imported cons. goods	2.5
ρ_I	ES of domestic and imported invest. goods	2.5
θ_p	Crice mark-up	0.2
ϕ_{MC}	Costs of adj. cons. imports	1
ϕ_{IC}	Costs of adj. invest. imports	1
ϕ_b	Adj. par. in transaction cost of issued bond	0.00001
ι	Habit persistance	0.8
χ	Inverse of Frisch elasticity of labor supply	2.5
ς	Share of Keynesian Households	0.5
ϕ_I	Investment adjustment costs	3
δ	Depreciation rate of capital	0.03
ρ	ES of capital and labor	0.5
μ	Quasi-capital share	0.12
ξ_p	Calvo price contract par. for domestic goods	0.92
ξ_m	Calvo price contract for imported goods	0.92
ξ_w	Calvo price par. contract for wages	0.90
θ_W	Wage mark-up	1/3
γ_π	Monetary policy rule parameter	1.5
γ_x	Monetary policy rule parameter	0.125
$\gamma_{\Delta x}$	Monetary policy rule parameter	$\gamma_x/2$
γ_i	Monetary policy rule parameter	0.7

Chapter 4

Main Results

In this chapter I consider the effect of unilateral increase of tariffs on both the US and China and future possibility of trade war if China decides to retaliate. The sector S&A represents the sector of aluminum and steel, and accounts relatively small portion of import for both of the economies. In the analysis I consider A&S be low substitutable with others goods.

4.1 Import tariff increase on Sector of A&S

In this section, I will explore the effects of unilateral tariff increase on A&S sector. Recently, the US announcement that they will increase their tariff on aluminium import by 25 percent and on all steel imports by 10 percent coming from China. Given the relative shares of aluminum and steel in the US import, overall it means about 20 percent increase on all A&S import.

Figure 4.1 presents the effects of the US import tariff increase on all A&S products from China by 20 percent. As a result, the A&S import level decreases by 28 percentage point

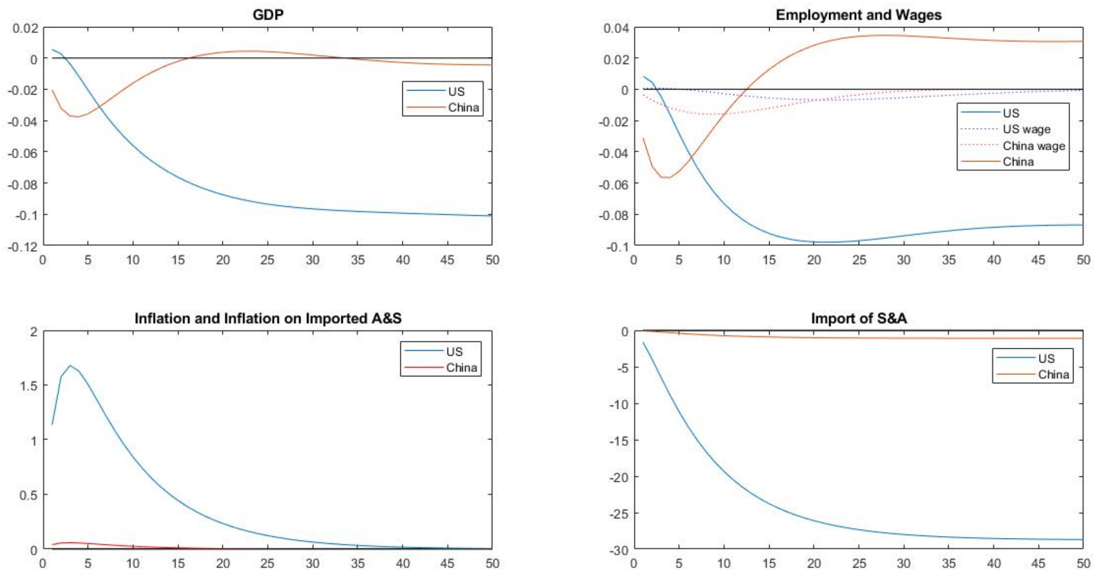

Figure 4.1: Increase in Import tariff on A&S Sector

for the US, which is the direct effect of increased tariff on that sector. The A&S sector accounts only for 0.1 percent of GDP, so it is still relatively small share in all US import. In fact, the unilateral tariff shock declines total import of US about 0.5 percentage point only (Figure 4.4). As a result, the prices of imported A&S goods increases, reaching its maximum of 1.6 percentage point, which increases the overall price of imported goods. The increase in prices of A&S and low substitutabiliy of A&S with other factor goods makes the production in this sector expensive, negatively affecting overall level of production of A&S , hence labor and wages. As the tariff decreases the export of the US (which is, due to the two-country framework, is the same as imports of China), and import to the US, the employment and wages will decline. The wages in the US decrease as much as 0.006 percentage point, while the employment decreases by 0.1 percentage point. The GDP in US also decreases, because of the decrease in employment level and combined with the overall decrease in terms of trade. The results are similar for China. The export and import decline as a direct impact of tariff increase. As a result, the employment and wages

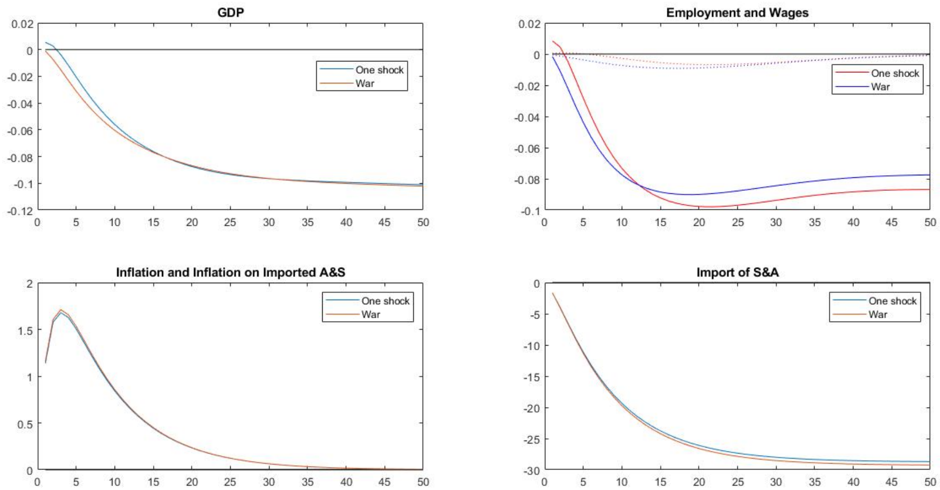

Figure 4.2: Bilateral Increase in Import Tariffs: US

also decrease with a similar argument as in the US case. The GDP declines as much as 0.03 percentage point.

4.2 Trade War

Now assume that not only US increases tariffs by 20 percent, and China decides to increase tariffs on A&S imports by 10 percent in return.

Figure 4.2 presents the effects of unilateral import tariff increase from the US side and the effect of tariff war for the US economy. The results are not very different. In case of war, US A&S goods become expensive for China as well, so it will cut down the export (Figure 4.3, the imports of by as much as 14 percentage point). As export decreases, the demand for A&S from China decrease. In case of trade war, the effect on wage and employment is worse than in the case of unilateral shock. At the beginning, there is a high inflation in the US in case of trade war, but, once the the relative prices adjust, we see that China's retaliation has a favorable impact overall inflation in the US.

Figure 4.3 presents the comparison of one way tariff shock to trade war case for China.

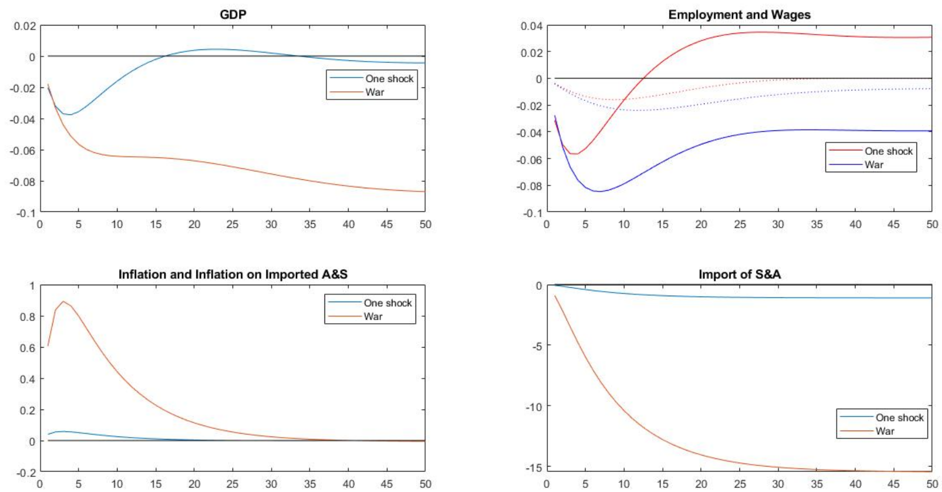

Figure 4.3: Bilateral Increase in Import Tariffs: China

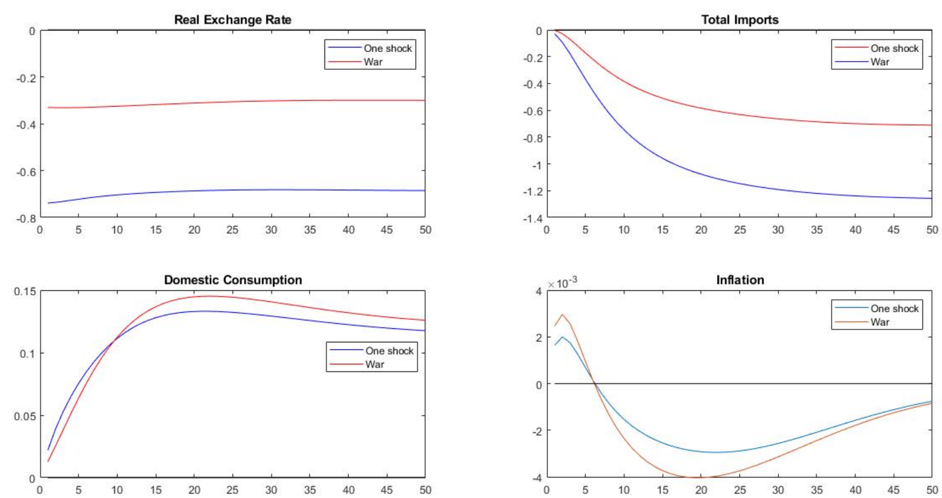

Figure 4.4: Bilateral Increase in Import Tariffs: US

The decline in China's GDP is sufficiently higher in case of trade war, then in case of tariff increase on China's exports. Import of S&A decreases about 15 percentage point because of imposed tariff barriers. The wages and employment decrease more in case of the trade war, as trade war substantially offsets the real appreciation of the dollar (Figure 4.4).

Figure 4.4 presents the result of trade shock on real exchange rate, total imports, domestic consumption, and inflation in US. Trade war substantially offsets the real appreciation of the dollar. Trade war also results to increase in domestic consumption. The overall inflation in the economy is positive, though negligible. Trade war results in decrease in overall import level as much as 1.2 percentage point.

Chapter 5

Conclusions

This study has been focused to analyse the macroeconomic impacts of trade policy. To analyze the recent trade dispute between US and China, I used two-country version of the New Keynesian DSGE model, and calibrated in a way to match with general features of the US and China. The study concludes that in general unilateral tariff shocks leave an adverse effect on most of the macroeconomic indicators of both economies, which is worsened in case of the trade war. The study still has much limitations and road for further extension and improvements. First of all, it is not realistic to assess the true affects of tariff shocks in two-country model version. While the import tariff hurts the A&S sector, the US has an opportunity to import the goods from other countries, e.g. EU. In that case the trade effects would be not that substantial. Same applies for China, as after the tariff shock, it has the option to export its goods to third countries. Therefore, two-country version puts a limitation on the results. For further research , it would be interesting to extend the model into 3 country one to capture the above mentioned limitations and see the effects on third countries as well.

Chapter 6

Appendix

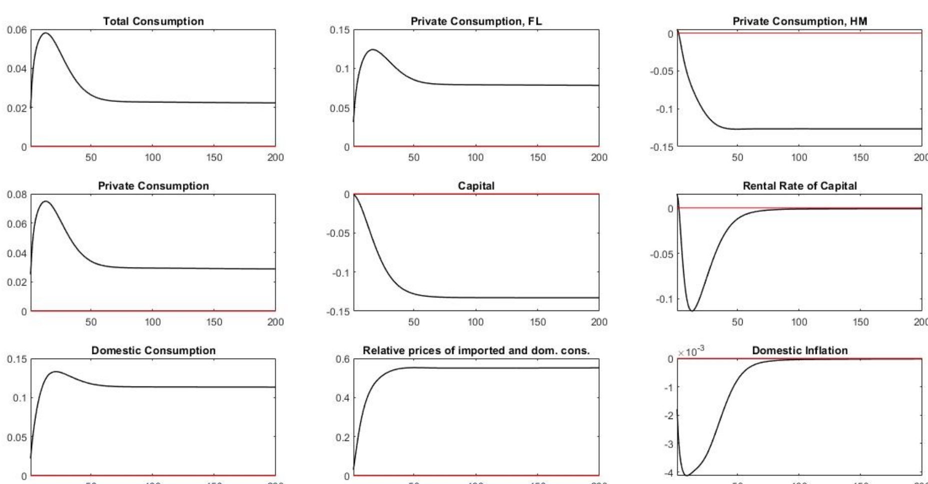

Figure 6.1: Some Impulse responses: 20 percent shock to US imports A&S sector

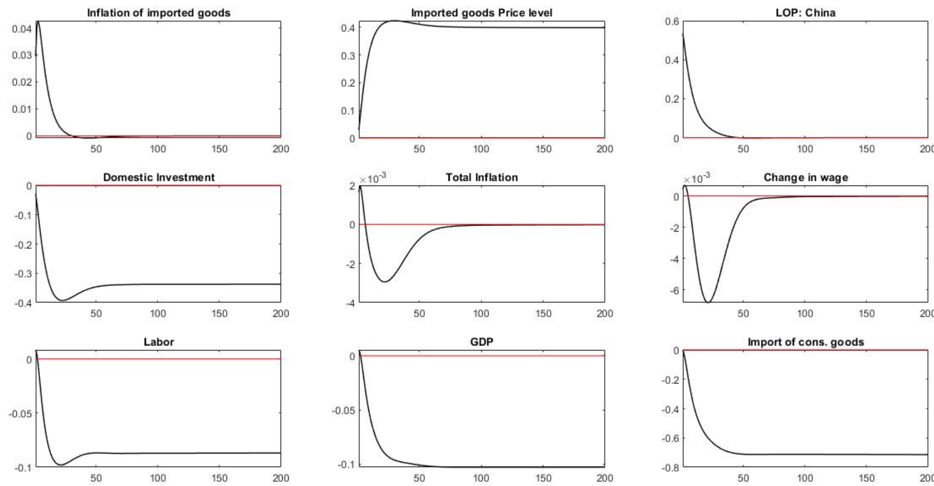

Figure 6.2: Some Impulse responses: 20 percent shock to US imports A&S sector

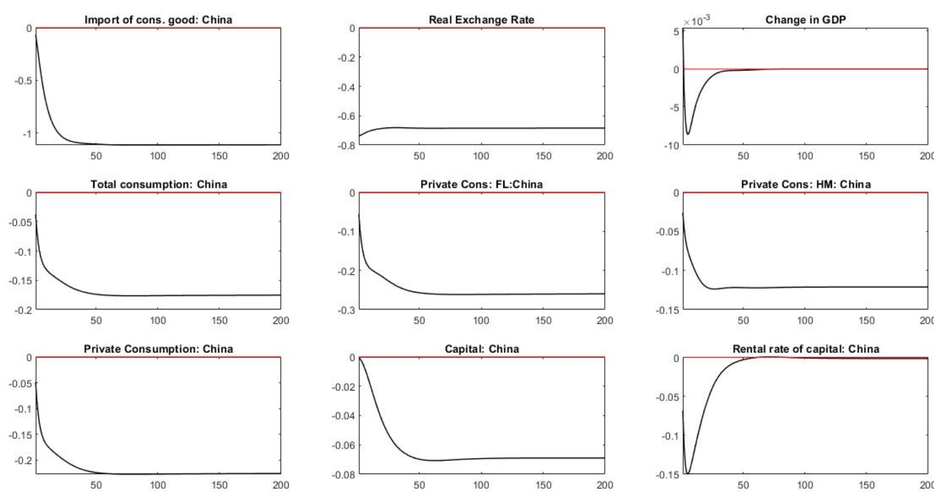

Figure 6.3: Some Impulse responses: 20 percent shock to US imports A&S sector

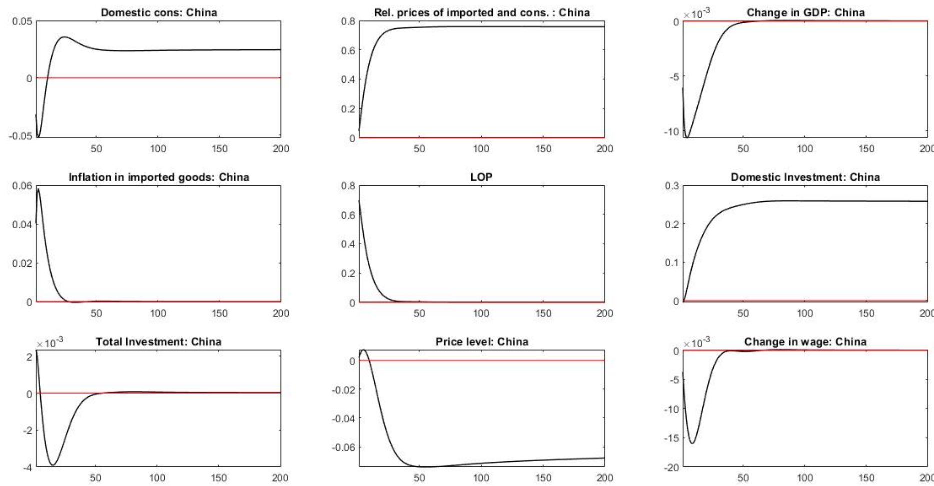

Figure 6.4: Some Impulse responses: 20 percent shock to US imports A&S sector

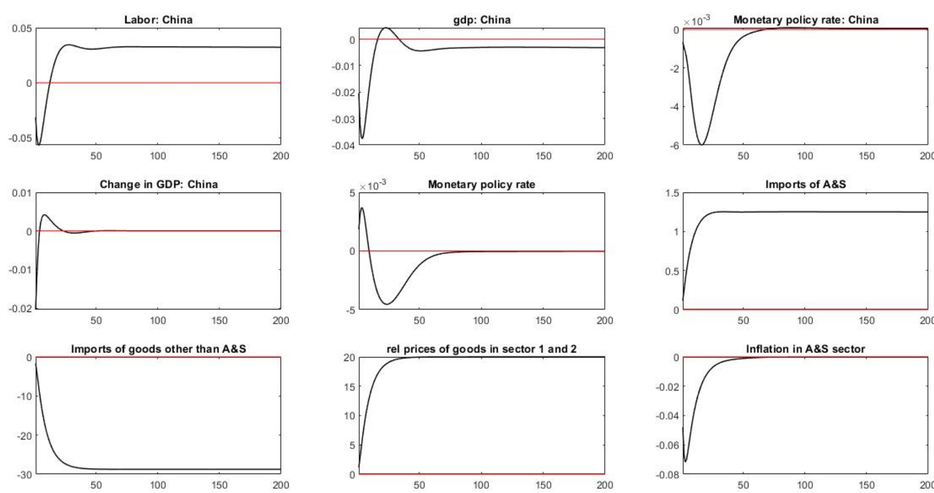

Figure 6.5: Some Impulse responses: 20 percent shock to US imports A&S sector

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