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Turhan, Ibrahim M. and Arslan, Yavuz and Kılınc, Mustafa

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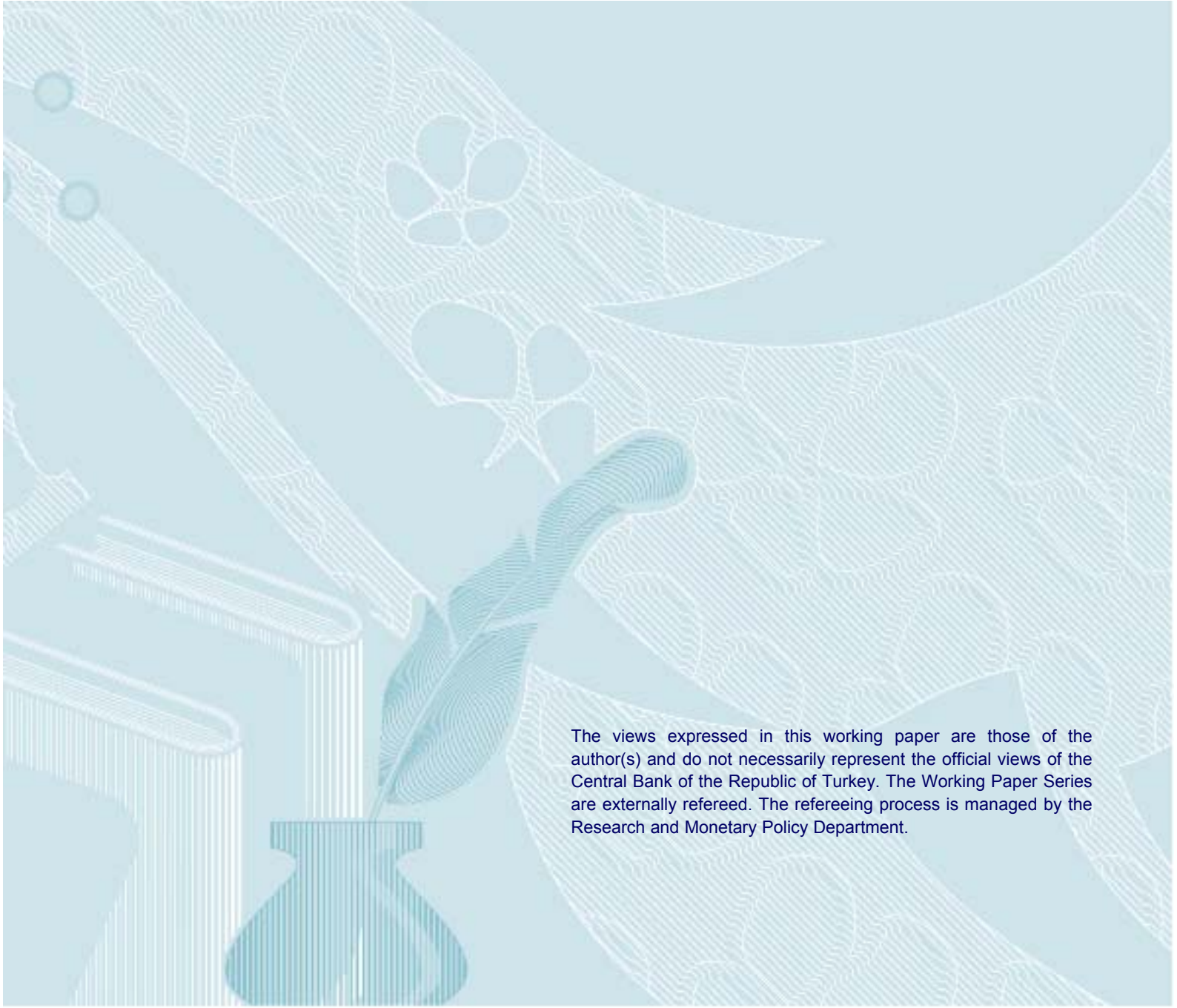
Yavuz ARSLAN
Mustafa KILINÇ
M. İbrahim TURHAN

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Address:
Central Bank of the Republic of Turkey
Head Office
Research and Monetary Policy Department
İstiklal Caddesi No: 10
Ulus, 06100 Ankara, Turkey

Phone:
+90 312 507 54 02

Facsimile:
+90 312 507 57 33



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Global Imbalances, Current Account Rebalancing and Exchange Rate Adjustments

Yavuz Arslan Mustafa Kılıncı M. İbrahim Turhan¹

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Abstract

We analyze the global imbalances and the required adjustments for rebalancing in current accounts and real exchange rates. We set up a two-country two-sector model for the US-China with two asymmetries. First, we assume that the size of China initially is one third of the US but its size becomes half of the US in the next ten years consistent with the fast growth expectations in China. Secondly, we assume that China initially runs a net export surplus against the US. Then we quantitatively study two adjustment scenarios. First scenario, called Slow Adjustment, assumes that in the process of growth, Chinese demand composition moves more towards domestic non-tradable sector. In this case, Chinese real exchange rate appreciates gradually and net export surplus also decreases slowly. Second scenario, called Quick Adjustment, assumes that in addition to the higher non-tradable share in output, net export surplus against US goes to zero quickly in five years. In this case, net export adjustment happens quickly and real exchange rates in China also appreciate faster and at a higher rate than Slow Adjustment case. Even though, global imbalances are eliminated faster in the Quick Adjustment case, high real appreciation in China hurts importers in the US. A comparison in terms of output shows that Slow Adjustments is preferred for both countries.

Key Words: Global imbalances, Current accounts, Exchange rate adjustments.

Jel Classification: F32, F36, F41

¹Central Bank of the Republic of Turkey, Istiklal Cad. No:10, Ulus, Ankara, Turkey. Phone: +90-312-507 5000. The views expressed in this paper do not necessarily represent those of Central Bank of the Republic of Turkey or its staff.

1 Introduction

Global imbalances are seen as one of the main driving forces of the global economic crisis and have been taken responsible for the weak recovery thereafter. Since the 2009 Pittsburgh Summit, where leaders of the Group of Twenty (G-20) countries committed to work in a coordinated way and thus adopted “the Framework for Strong, Sustainable, and Balanced Growth”, this issue has become a major discussion topic both in research and policy circles. The backbone of the framework is a multilateral process through which root causes and the impediments to adjustment in those countries are to be identified and solutions are to be recommended. Within this context, countries having large imbalances, such as USA and China deserve a special attention. Although there is a unanimous agreement on the unsustainability of such large imbalances, yet countries seem to diverge on how (fast) to diminish them. While deficit country (e.g. USA) insists on immediate adjustment through nominal appreciation of the currency of surplus country (e.g. China), the later prefers a more gradual move, mainly through real appreciation. In this paper, we analyze how the given level of imbalances between the US and China would disappear under different adjustment scenarios. For this purpose, we set up a two-country (the US and China) two-sector (tradables and non-tradables) world economy with endogenous labor decision and capital accumulation. There are two asymmetries across the countries in our model. First, we assume that initially Chinese output is one third of the US output. However, given the faster growth in China, we also assume that Chinese output increases to the half of the US output in ten years. Second, we assume that China runs a 5.5 percent net export surplus against the US. With these initial arrangements, we want to make a realistic calibration of the model similar to the data. Then we analyze the impact of different adjustment scenarios.

The two scenarios that we compare, called Slow and Quick Adjustments, look at the implications for the real exchange rate, terms of trade and output. Slow Adjustment case assumes that along with the fast growth in China, demand moves towards domestic nontradable sectors. In this case, Chinese terms of trade depreciates due to fast growth in China, which increases the supply of Chinese traded goods vis-a-vis the US traded goods. However, the move in the domestic demand towards the nontradable goods appreciates the Chinese currency. Overall US producers benefit from the cheap Chinese goods and the net export surplus of China decreases from 5.5 percent of output to 3 percent of output in ten years. In contrast, with the Quick Adjustment scenario we assume that in addition to faster growth and demand shift towards nontradable goods, Chinese net exports are forced to go to zero in five years. This additional and fast adjustment of the net exports leads to a large terms of trade and real exchange rate

appreciation. More expensive tradable good imports from China hurts the producers in the US. When we compare the results of the two scenarios in terms of final outputs in countries, we find that both countries get a higher output profile under the slow adjustment case.

In the literature, there are lots of studies looking at the several dimensions of the adjustment process of global imbalances. For example, Obstfeld and Rogoff (2005, 2007) quantifies the required changes in the real exchange rates for imbalances between the US and the rest of world to clear. They use a multi-country endowment economy for their model and make a static analysis. Similarly, Mejean et al. (2011) uses a three-country endowment economy of the world with tradable and nontradable sectors. They estimate size of required adjustment in terms of trade and real exchange rates to decrease the current account deficit of the US by 1 percent of the GDP. In contrast to these endowment models, Faruqee et al. (2007, 2008) set up a production economy of four blocks of countries and they first try to present cases such that the given level of imbalances can be generated in the model and then they analyze the effects of different policies on the imbalances. Their study offers a very rich framework to study the dynamics of imbalances and the interactions of several structural factors such as tariffs and competition. Similarly, Vogel (2010) uses a multi-region macroeconomic model with Forex intervention to study the China's external surplus. Author looks at the dynamics of imbalances and finds that floating the Chinese currency would contribute to the balancing of imbalances. Straub and Thimann (2010) studies the adjustment in China in a multi-country model. They look at the possible adjustment process under different scenarios such as productivity growth, labor supply movements and flexible exchange rates. Our paper is also a production economy model. We have two countries and two-sectors in our model, which is simpler than the models of Faruqee et al. (2007, 2008), Vogel (2010) and Straub and Thimann (2010). But distinct from these papers and from the related literature, we explicitly study the speed of adjustment process and find that quantitative implications can differ significantly between different speed scenarios. This finding points to the importance of the pace of the adjustment as also emphasized by Krugman (2007).

Plan of the paper is as follows: Section 2 presents the data, Section 3 presents the model and Section 4 studies the simulation results regarding the adjustment scenarios. Section 5 concludes.

2 Data

Figure 1 plots the current account balance data from IMF-IFS database for both countries as percent of GDP from 1990 to 2010. Around 1990, both China and the US had smaller current account balances. Towards the end of the 1990s, China has started accumulating current account surpluses and the US started running current account deficits. However, even at the end of the 1990s, current account imbalances in both countries were less than 5 percent (1.4 in China and -3.2 in the US). Imbalances in the current accounts started growing larger in 2000s. By 2006, current account as a share of GDP was -6 percent in the US and 9 percent in China. Global financial crisis of 2008-2009 decreased the level of imbalances in countries from their peaks somehow. But the current account balances by the end of 2010 were 5.2 percent in China and -3.2 percent in the US, still significant numbers.

Figure 2 presents the foreign asset positions of China and the US starting from 1990. This data is taken from an updated and extended version of the dataset constructed by Lane and Milesi-Ferretti (2007). As shown in the graph, in 1990, both countries had very low levels of net foreign asset positions (2 percent in China and -5.6 percent in the US). However, with the persistent current account surpluses in China and deficits in the US, net foreign asset positions started to move to large values. By 2007, China's positive net foreign asset position reached 22 percent of its GDP. In contrast, the US recorded a negative foreign asset position at 17 percent of its GDP. These numbers support that imbalances have also been growing as a stock. In Figure 3, we also check the bilateral trade positions of the US and China to see how much of the total imbalances are coming from bilateral trade in goods and services. This data comes from the US Department of Commerce and PRC National Bureau of Statistics. We see that for the years 2007-2010, almost all of the net export surplus of China comes from its trade with the US. In these years, Chinese net export surplus against the rest of the world was an average of 5.28 % of GDP and against the US it was 5.63 %. In the same period, the US net export deficit against the rest of the world was 4.86 % of its GDP and against China it was 1.8 %. These numbers support our numeric exercise in the paper. We assume that initially China runs a net export surplus of 5.5 % against the US and also assume that the Chinese GDP is one thirds of the US GDP. Then this would imply that the US also runs a net export deficit of 1.83 % against China in our exercise. These numbers are closely in line with the bilateral trade flows between the US and China as shown in Figure 3. In the data most of the current account is from the trade balance and the foreign income balance is a small portion. However, in the model, we make our simulations and present our results in terms of net exports. To be more consistent and proper with the use of these terms, up to the model part we use terms of 'current

accounts’ and ‘global imbalances’ as it is the more common to use these terms when talking about the data. In the model part we use the term of ‘net exports’ to be more specific.

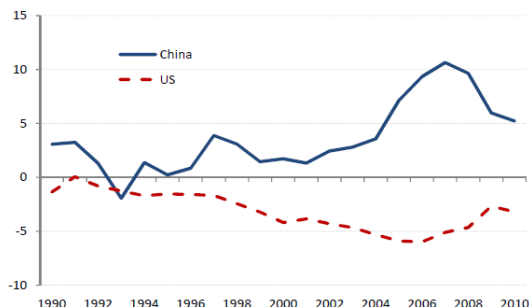


Figure 1: Current Accounts as % of GDP

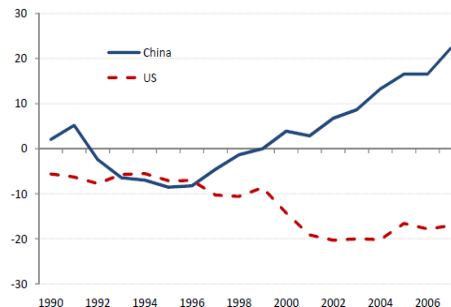


Figure 2: Net Foreign Assets as % of GDP

These imbalances were not confined to the US and China, and large current account imbalances have been observed in most economies. Figure 4 shows average of the absolute values of current account balances for 64 developed and developing countries over the period of 1990-2010¹. In 1990, average current account balance (in terms of absolute values) was 3.4 percent of the GDP. The current account imbalances increased slowly in 1990s, and gained speed in 2000s reaching to 7 percent of GDP in 2008. With global financial crisis of 2008-2009, imbalances decreased to 4.8 percent as of 2010. This number shows that global imbalances still remains large even after the global crisis.

¹Data is from IMF. Countries are: Albania, Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Cyprus, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Finland, France, Germany, Greece, Guatemala, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, United States, Uruguay, Venezuela, Vietnam.

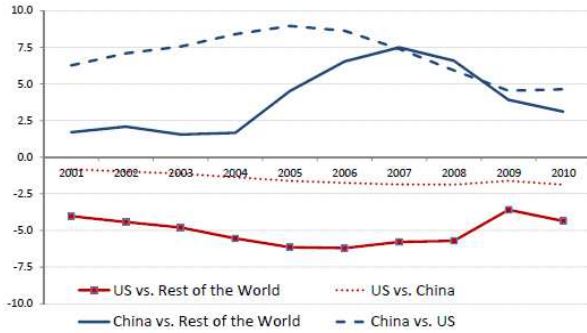


Figure 3: Net Export Balance as % of respective GDP

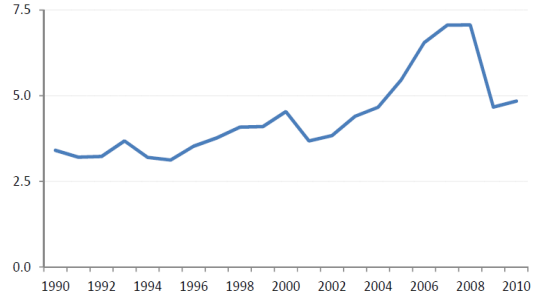


Figure 4: Average Current Accounts (Absolute Value) as % of GDP for 64 Countries

These "global imbalances" have attracted lots of attention from academia and policy makers. Some papers in the literature explain these imbalances as equilibrium outcomes of several market forces. For example, in an endogenous portfolio model, Caballero et al. (2008) show that ability of the US to issue safe assets leads to current account deficits in the US. Similarly, Mendoza et al. (2009) set up a two country (developing vs. developed) endogenous portfolio model. They show that financial market imperfections in the developing countries makes them demand safe assets from developed countries. This effect produces current account surpluses in developing countries. The policy implications and required adjustments in exchange rates to close the imbalances are also discussed extensively in the literature. For example, in a series of papers, Obstfeld and Rogoff (2001, 2005, 2007) analyze the sustainability of the US current account deficits and present quantitative results on how much the terms of trade and real exchange rate needs to change in case of a correction in current accounts. Krugman (2007) notes that not only the size, but also the speed of adjustment is important. Global imbalances have implications for the international monetary system also as shown by Salvatore (2005, 2011) and McKinnon and Schnabl (2011)².

In our model, we make a dynamic quantitative analysis of the required adjustments in the exchange rates to lessen the global imbalances. Our analysis is dynamic in the sense that we include time dimension into the adjustments by studying different speed scenarios. To make the analysis more realistic, we also

²There is a vast literature on global imbalances. For some of the papers, see: Bernanke (2005), Blanchard et al. (2005), Calvo and Talvi (2006), Edwards (2005), Eichengreen (2006), Engel and Rogers (2006), Faruqee et al. (2007), Feldstein (2011), Fogli and Perri (2006), Ghironi et al. (2007), Gourinchas and Rey (2007), Lane and Milesi-Ferretti (2007), McKinnon (2009), Mejean et al. (2011), Rogoff (2007), Zhang and Wan (2008).

incorporate the fast growth expectations and the structural demand shifts in China.

3 Model

In this section, we develop a two-country and two-sector, tradable and non-tradable, production economy model with a single bond. Our world economy consists of two countries, one representing a developed country (the US) and the other representing emerging country (China). Countries are indexed as $i = U, C$ representing the US and China respectively. In each country firms use capital, labor and sector specific technology to produce perfectly tradable inputs and nontradable inputs. There are intermediate goods firms in each country which aggregate tradable inputs from the other country with the tradable inputs that they produced to form tradable intermediate goods for the final good. The final good firms combine tradable intermediates and nontradable inputs to form the final good. Production sharing takes place in tradable inputs, so countries use both home and foreign tradable inputs to produce their respective tradable intermediate goods. Then, they combine this tradable intermediate good with non-tradable input to produce their distinctive final goods, which later to be consumed or invested by the households of each countries.

Our model has a similar structure with that of Backus, Kehoe and Kydland (1995), Stockman and Tesar (1995) and Corsetti et al. (2008). Different from these models we abstract from uncertainty since we are interested in movements in the steady state in contrast to movements around the steady state.

3.1 Firms' problem

The perfectly competitive tradable good producer firms in each country combine capital and labor with their sector specific technology in a Cobb-Douglas production function to obtain the tradable good. The production function in mathematical form is:

$$X_{i,T,t} = \theta_{i,T,t} n_{i,T,t}^\alpha k_{i,T,t}^{1-\alpha} \quad i = U, C. \quad (1)$$

Total amount of tradable good produced is $X_{i,T,t}$, the technological level (productivity) of the firm is denoted as $\theta_{i,T,t}$, the amount of labor employed in the production is $n_{i,T,t}$, and the amount of capital used is $k_{i,T,t}$. The subscript i is used to denote the countries, subscript T is used to denote the good that is tradable, and the subscript t is used to denote time period. After production takes place at

time t , tradable firm in country i sells $X_{iC,T,t}$ part of its output to China and $X_{iU,T,t}$ part to the U.S. Consequently, Chinese exports to the U.S. (or the U.S. imports from China) will be $X_{CU,T,t}$ and Chinese imports from the U.S. (or the U.S. exports to China) will be $X_{UC,T,t}$. Remaining parts of $X_{CC,T,t}$ and $X_{UU,T,t}$ are used in home tradable intermediate goods production in China and the U.S., respectively. Therefore, we have the following resource constraint for tradable input production:

$$X_{i,T,t} = X_{iC,T,t} + X_{iU,T,t} \quad i = U, C. \quad (2)$$

There is production sharing between countries in the sense that both countries use each other's tradable inputs to produce their respective tradable intermediate goods. We assume that there are perfectly competitive intermediate tradable good producers in each country that combine tradable inputs from their own country with imports of tradable inputs from the other country to produce intermediate tradable goods. Intermediate tradable good producers use a constant elasticity of substitution production technology as follows

$$Y_{i,T,t} = \left[v_i^{\frac{1}{\kappa_i}} X_{Ci,T,t}^{1-\frac{1}{\kappa_i}} + (1-v_i)^{\frac{1}{\kappa_i}} X_{Ui,T,t}^{1-\frac{1}{\kappa_i}} \right]^{\frac{\kappa_i}{\kappa_i-1}} \quad i = U, C \quad (3)$$

where κ_i is the elasticity of intertemporal substitution between the U.S.'s tradable input $X_{Ui,T}$ and China's tradable input $X_{Ci,T}$, and v_C is the share of China's tradable input in country i 's intermediate tradable goods production, where $v_C = 1 - v_U$. Taking China's tradable input price as numeraire ($P_{C,T} = 1$) and denoting relative prices of the U.S. tradable inputs as $P_{U,T}$, we can derive the tradable intermediate goods price index for the U.S. and China as follows:

$$P_{i,T,t} = \left[v_i + (1-v_i) P_{U,T,t}^{1-\kappa_i} \right]^{\frac{1}{1-\kappa_i}} \quad i = U, C \quad (4)$$

There are also perfectly competitive nontradable good producers in each country which operate similar to the tradable good producer firms. They produce with the Cobb-Douglas functional form but with different technological levels:

$$X_{i,N,t} = \theta_{i,N,t} n_{i,N,t}^\alpha k_{iN,t}^{1-\alpha} \quad i = U, C. \quad (5)$$

Total amount of nontradable good produced is $X_{i,N,t}$, the technological level (productivity) of the firm is denoted as $\theta_{i,N,t}$, the amount of labor employed in the production is $n_{i,N,t}$ and the amount of capital used is $k_{i,N,t}$. The subscript N is used to denote that the good is nontradable.

Once the international trade in inputs between countries takes place and production of intermediate tradable goods is performed, competitive final good producers in each country combine their own intermediate tradable output with country's non-tradable inputs to produce the final goods. Final good producers also use constant elasticity of substitution production technology:

$$Y_{i,t} = \left[\gamma_i^{\frac{1}{\eta_i}} Y_{i,T,r,t}^{1-\frac{1}{\eta_i}} + (1-\gamma_i)^{\frac{1}{\eta_i}} X_{i,N,t}^{1-\frac{1}{\eta_i}} \right]^{\frac{\eta_i}{\eta_i-1}} \quad i = U, C \quad (6)$$

where η_i is the elasticity of intertemporal substitution between intermediate tradable goods $Y_{i,T,r}$ and non-tradable inputs $X_{i,N}$, and γ_i is the share of tradable goods in the final goods production. From the optimization problem of the firm, we can derive the final goods price index as follows:

$$P_{i,t} = \left[\gamma_i P_{i,T,r,t}^{1-\eta_i} + (1-\gamma_i) P_{i,N,t}^{1-\eta_i} \right]^{\frac{1}{1-\eta_i}} \quad i = U, C \quad (7)$$

For both countries there are two more relevant prices, i.e. terms of trade and real exchange rates. We define terms of trade, ToT , from the perspective of China, as the ratio of its export prices to its import prices; and real exchange rate, ReR , as the ratio of Chinese final goods prices to the U.S. final goods prices:

$$ToT_t = \frac{P_{C,T,t}}{P_{U,T,t}} \quad \text{and} \quad ReR_t = \frac{P_{C,t}}{P_{U,t}} \quad (8)$$

An increase in the ToT means an appreciation of terms of trade for China by making its export prices more expensive or import prices less expensive. An increase in ReR means an appreciation of real exchange rates for China and a depreciation for the U.S. In the simulations, we will be also interested in the dynamics of net exports over output, which are defined as:

$$nxy_{i,t} = \frac{P_{i,T,t} X_{i,T,t} - P_{j,T,t} X_{j,T,t}}{P_{i,t} Y_{i,t}} \quad i, j = U, C \quad i \neq j$$

3.2 Households' problem

Households provide labor services $n_{i,T,t}$ to tradable and $n_{i,N,t}$ to nontradable firms in their countries at the wage rates of $w_{i,T,t}$ and $w_{i,N,t}$. They also own the capital stock in both sectors ($k_{i,T,t}$ and $k_{i,N,t}$) and rent it to the firms at rates $q_{i,T,t}$ and $q_{i,N,t}$. Both labor and capital are mobile between sectors within the country but they are immobile between countries. Households also hold an internationally traded bond $B_{i,t}$ that is in zero net supply. So income of households consists of wage income from labor supply,

rent income from capital supply, and the interest income from the bond. Households use their income to finance their consumption $c_{i,t}$, investment in tradable and nontradable capital, and to buy new bonds. They also pay adjustment costs for capital and bond changes. Then the budget constraint for households in country i is,

$$\begin{aligned}
& P_{i,t}c_{i,t} + P_{i,t}[k_{i,T,t+1} - (1 - \delta)k_{i,T,t}] + P_{i,t}\frac{\kappa}{2}(k_{i,T,t+1} - k_{i,T,t})^2 \\
& + P_{i,t}[k_{i,N,t+1} - (1 - \delta)k_{i,N,t}] + P_{i,t}\frac{\kappa}{2}(k_{i,N,t+1} - k_{i,N,t})^2 + P_{B,t}B_{i,t+1} + P_{B,t}\frac{\Omega}{2}(B_{i,t+1} - \bar{B})^2 \\
= & B_{i,t} + w_{i,T,t}n_{i,T,t} + w_{i,N,t}n_{i,N,t} + q_{i,T,t}k_{i,T,t} + q_{i,N,t}k_{i,N,t}
\end{aligned} \tag{9}$$

where κ is the adjustment cost parameter for capital stock, δ is the depreciation rate and Ω is the adjustment cost parameter for bond holdings. Representative households in both economies have constant relative risk aversion type of preferences over consumption of the final goods and labor:

$$U_{i,t}(c_{i,t}, n_{i,T,t}, n_{i,N,t}) = \frac{[c_{i,t}^\psi(1 - n_{i,T,t} - n_{i,N,t})^{(1-\psi)}]^{(1-\sigma)}}{1 - \sigma}$$

where ψ is used to calibrate the steady state value of total labor and σ is the risk aversion parameter. Households maximize the net present value of their lifetime utility $\sum_{t=0}^{\infty} \beta^t U_{i,t}(c_{i,t}, n_{i,T,t}, n_{i,N,t})$ subject to the budget constraint.

3.3 Resource Constraints

Since there is no trade in final goods, final goods in each country are used for consumption, investment and adjustment costs and we have the following resource constraint for country i :

$$\begin{aligned}
Y_{i,t} = & c_{i,t} + [k_{i,T,t+1} - (1 - \delta)k_{i,T,t}] + [k_{i,N,t+1} - (1 - \delta)k_{i,N,t}] \\
& + \frac{\kappa}{2}(k_{i,T,t+1} - k_{i,T,t})^2 + \frac{\kappa}{2}(k_{i,N,t+1} - k_{i,N,t})^2 + \frac{\Omega}{2}(B_{i,t+1} - \bar{B})^2 \quad i = U, C.
\end{aligned} \tag{10}$$

Also there is only one bond in the international financial markets and the net supply is zero, giving us:

$$B_{U,t} + B_{C,t} = 0 \tag{11}$$

3.4 Calibration

Most parameter values chosen are standard and are from the literature. We follow mostly Corsetti et al. (2008) to calibrate our parameters. For now, we assume that all the model parameters are symmetric

across two countries except the sizes of the countries. Productivity ratios are chosen such that the U.S. final production is 3 times of Chinese final production, i.e. $P_{U,t=1}Y_{U,t=1} = 3P_{C,t=1}Y_{C,t=1}$. Then we assume that over the ten years, the Chinese GDP will reach to the half size of the US GDP. The assumption that China will grow from one third to half of the US GDP in ten years is based on the recent growth numbers. Using World Development Indicators of World Bank, by 2008, the US GDP was 14.3 trillion dollars and the Chinese GDP was 4.5 trillion dollars giving a ratio of around one third. Average real GDP growth over the period of 1980-2008 (excluding recent crisis period) was 10 % in China and 2.87 % in the US. If these growth numbers continue, then the Chinese output would reach half of the US output in seven years. But to be cautious, we assume that this convergence takes place in ten years.

Rest of the parameters are chosen as follows. α is chosen such that labor share in income is $2/3$ in both tradable and nontradable sectors. Intermediate tradable producers combine home tradable inputs with imported tradable inputs. The parameter that governs the home input share in intermediate tradables production, v , is chosen as 0.72, which produces a home bias. The elasticity of intertemporal substitution between home tradable inputs and imported tradable inputs, κ , is chosen as $3/2$. The share of intermediate tradables goods in final goods, γ , is 0.55. The elasticity of intertemporal substitution between tradable intermediate goods and nontradable inputs, η , is chosen as $3/4$. This value is smaller than the one between home and foreign tradables so that tradables are more substitutable than nontradables and nontradables. Depreciation rate of capital, δ , is the annual depreciation rate 10%. Consumption share in Cobb-Douglas utility function, ψ , is chosen as 0.35 to match the steady state total labor of $1/3$. Risk aversion parameter, σ , is the standard value of 2. Discount factor for households, β , is $1/1.04$, implying a risk-free interest rate of 4%. Time period under this calibration is one year. An important remaining value to calibrate is the bond holdings or net exports of the countries. We calibrate the steady state value of the Chinese bond holdings, B_C , as to match the net exports over GDP ratio of 5.5% for China. In other words, China will run a net export surplus against the U.S. in the initial steady state. All the parameter values are summarized in Table 1.

4 Simulations

In this part, we look at two different simulations concerning our model. At the calibrated initial steady state at time $t = 1$, China runs a net export surplus over GDP of 5.5% against the U.S. and ratio of Chinese GDP to the US GDP is $1/3$. Other than these two differences across the countries, all the

remaining structural factors are the same. Then, in the first scenario, which is called Slow Adjustment, we let China to grow both in tradable and nontradable sectors along with a slow shift from tradables to nontradables in the final goods production. We let all these changes to happen in one period increments such that at period $t = 10$ Chinese GDP grows to half of the US GDP. With these changes taking place, we follow what happens to net exports, real exchange rates and as a result to global imbalances. In the second scenario, which is called Quick Adjustment, in addition to the changes in the first scenario, we also force net exports of China to fall to zero quickly in four periods. Then we compare the results of simulations across these two scenarios. Here, in these simulations we solve for new steady states at each period with the new parameters, not the transition path after a structural parameter changes. However, given that changes are in small increments, the time period is one year and the adjustment cost parameters are very small, we can assume that model would converge to new steady state quickly around a year.

In the first scenario, we start with the initial points described above and then there are two main changes in the Chinese economy. First, both tradable and nontradable technology levels in China will improve over time. Also, consistent with the overall observation in other countries, we assume that tradable technology growth is more than two times that of nontradable sector. The assumption that over the convergence process productivity in the tradables grows faster than nontradables is based on the empirical evidence from the literature. For example, Strauss and Ferris (1996) show that in 14 OECD countries, over the period of 1970-1990, average productivity growth in tradables was around two times of average productivity growth in nontradables. Cova et al. (2010) shows that in emerging Asia and in China, for the period of 1975-2004, the productivity growth in tradables were around two times that of nontradables. Using these evidence, we make the assumptions that productivity growth in tradables will be larger than in nontradables. In the US, however there is no change in the technology levels. This does not mean that the U.S. economy does not grow in reality, but we assume that the U.S. economy is on its balanced growth path. Second, in the initial steady state, we have the share of nontradables in final production as 45%, and in the simulations we increase this ratio to 55% in China to reflect that as China gets richer its share of nontradable goods will increase. Exact parameter values are given in Table 2 for this scenario.

In Figure 5, we plot the results of first scenario with marked lines. With increases in the tradable technology of China, terms of trade will depreciate, i.e. Chinese tradable goods compared to the US tradable goods will become cheaper. This depreciation is more than 15% at the end. Since, Chinese goods

are much cheaper, Chinese exports to the US increases around 30%. Normally, Chinese tradable inputs and the US tradable inputs are substitutes, but with growth, China uses also more of the US tradable goods and Chinese imports from the US increases also around 15%. Then, combined overall effect of terms of trade depreciation and increased imports from the US leads to a decrease in the net exports of China from 5.5% to 3%. Another crucial element in this adjustment is that China does not change the initial international portfolio position to avoid decreases in the net exports. For the nontradable sector, since the substitutability between tradables and nontradables is low and there is a structural move towards the nontradable goods in GDP, production of nontradables also increase significantly. The move towards a higher share of nontradables in GDP works like a demand shocks for nontradable sectors and nontradable prices increase. This increase in the nontradables' prices compensates the depreciation effect and the real exchange rate appreciates in China as seen in the figure. The process itself also benefits the US in the sense that imports from China are cheaper now and as a result the intermediate tradables production increases in the US as well. Coupled with a small increase in the nontradable sector, overall GDP increases slightly in the US. In scenario 1, the adjustment of global imbalances is slow. Net exports decrease from 5.5% to 3% in nine years and appreciation of real exchange rate is less than double digit.

As an alternative case, we also ask what happens if the net export adjustment was larger and quicker. In this case, instead of leaving net exports to be determined in equilibrium for a given level of bond holdings, we force net exports of China to go to zero in four years by changing the international portfolio position. Therefore, this new scenario (Quick Adjustment) scenario includes exogenous movements of net exports in addition to other forces in first scenario. As presented in Table 3, in addition to the changes in Table 2, we have net exports as another parameter to change. It should be noted that, since with quick adjustment of net exports, real exchange rates appreciate more in China compared to the slow adjustment case, leading to higher GDP ratios also. To match the final GDP ratios of 0.5 for both scenarios, in the second scenario we increase technology parameters less to compensate the appreciation effect.

Figure 5 presents the simulations of second scenario where there is quick adjustment of net exports with smooth lines. Most contrasting change happens in net exports such that it moves from 5.5% to 0% in four years compared to a slow adjustment to 3% in nine years. To make this large and quick change in net exports, Chinese terms of trade needs to appreciate. At the same initial four periods, terms of trade appreciates around 9% making Chinese tradable inputs expensive. Consequently, since the US goods are cheaper in relative terms now, Chinese imports from the US increase around 20% in four years, much larger than the value of 7% in slow adjustment case. Also, since Chinese goods are more expensive,

Chinese exports to the US decreases around 12%, in stark contrast to the slow adjustment case where exports were increasing. This decrease in exports coupled with increase in imports enables the large adjustment in net exports of China. The terms of trade appreciation together with the structural shift towards nontradable goods lead to a large appreciation of real exchange rates in China, around 18% at the end compared to 6% in slow adjustment case.³ Overall the quick adjustment and large appreciation in China leads to a lower growth in GDP. The quick adjustment case is not also very beneficial for the US in terms of GDP except that it closes the global imbalances quickly. Since Chinese goods are more expensive now, the US intermediate tradable good producers will be able to buy less Chinese inputs and their production will be lower compared to balanced growth path and GDP will be also lower than balanced growth path equilibrium by around 1%.

Our result that slow adjustment is preferable is robust to parameter changes. For example, we also simulate the model with a lower elasticity of substitution between tradables and nontradables. In our benchmark case, we have an elasticity of $\frac{3}{4}=0.75$. Quantitative results of these two simulations are presented in Table 4. In the benchmark calibration with 0.75, we find that in slow adjustment, ToT would depreciate 16.57 %, and ReR would appreciate 5.73 %, in contrast to quick adjustment case where ToT would appreciate 5.60 %, and ReR would appreciate more 18.35 %. It seems that in quick adjustment, there is a faster correction in ReR, however, in terms of outputs; slow adjustment is preferable for both countries as seen in the table. When we simulate with a lower elasticity of 0.45 we find that our results are robust to this change. As before, we find that in slow adjustment, ToT would depreciate 8.22 %, and ReR would appreciate 10.57 %, in contrast to quick adjustment case where ToT would appreciate a lot 24.49 %, and ReR would appreciate a lot also 27.69 %. However, in terms of outputs, slow adjustment is still preferable for both countries. So all the directions of changes (appreciate/depreciate, increase/decrease) stay the same and main result of the paper that slow adjustment is preferable is robust. Only change happens in the magnitudes.

When interpreting our results regarding the adjustment process, we should keep in mind that our model is a real international business cycle model and does not include nominal variables, monetary or exchange rate policies. However, in some simple ways, we can infer about the dynamics of nominal variables, too. To give an example, the definition of real exchange rate in the model is $ReR_t = P_{C,t}/P_{U,t}$. If we had a nominal model, the new definition would be $ReR_t = P_{C,t}/(P_{U,t}E_{Y/\$,t})$, where $E_{Y/\$,t}$ is

³Obstfeld and Rogoff (2007) finds that between 17 and 64 percent depreciation of dollar is required for imbalances to clear. Mejean et al. (2011) finds that for a reduction 1 percent of GDP in current account deficit of the US, there needs to be a 15 percent depreciation of dollar. Our quantitative results are on the low side of these findings.

the nominal exchange rate showing how much Yuan an US Dollar worth. Let's assume that P_U is constant and ReR appreciates. In the real model, this happens through increase in the price level in China, whereas in the nominal model it happens through a combination of increase in domestic prices or nominal appreciation (a decrease in $E_{Y/\$}$). So even if monetary policy resists a nominal appreciation, as long as the country keeps open capital accounts in the international financial markets, then in equilibrium ReR would appreciate through higher domestic prices and all of the adjustment in ReR would still take place. But the real life policy options are much wider than this simple representation of policy. For example, in the model, portfolio side is taken exogenously and there are no valuation effects. In real life policy environment, monetary policy can endogenously play with the portfolio position of the country through FX reserve policy and therefore affect the level of real exchange rates⁴.

5 Conclusion

In this paper, we analyze the role of real exchange rate adjustments in global imbalances and current account rebalancing. We quantitatively study how much terms of trade and real exchange rate between the US and China would change under different adjustment scenarios. We take into the account the time dimension explicitly by looking at the speed of adjustments. To make the analysis more realistic, we also incorporate into the analysis the fast growth expectations and structural demand shifts in China. We quantitatively study two cases. First case, called Slow Adjustment case, assumes that in ten years China grows from one third to half of the US GDP and its domestic demand composition moves more towards nontradable goods. Fast growth in China increases the supply of Chinese goods and depreciates the terms of trade. The cheaper imports from China benefits the tradable producers in the US. Shift of demand towards nontradables in China, however, appreciates the Chinese currency. Overall, net export surplus of China decreases from 5.5 percent to 3 percent in ten years. In the second case, called Quick Adjustment scenario, in addition to first scenario, we assume the Chinese net export surplus goes to zero in five years. This required quick adjustment of current accounts leads to a large appreciation of term of trade. The resulting high prices of imports from China hurts the tradable producers in the US. Demand shift towards nontradable goods in China puts extra appreciation pressures on the Chinese currency leading to a much higher appreciation in the second case. Overall, in the quick adjustment case, net

⁴If China can successfully resists against appreciation pressures, then our results would be upper bounds of the possible adjustment process. For discussions on the fixed vs floating exchange rates for imbalances, see Straub and Thimann (2010), Vogel (2010) and Mejean et al. (2011).

export imbalances decrease faster, terms of trade appreciates in contrast to a depreciation and current appreciation is much larger compared to the slow adjustment case. The distinction between the two scenarios corresponds roughly the difference between the substitution and income effects in a standard demand analysis. Whilst the quick adjustment situation would only have a similar effect as substitution effect, and result in substitution of US goods for those that would have previously imported from China, in the slow adjustment scenario both income and substitution effects would be the case, because Chinese consumers, thanks to real rather than nominal appreciation, would at least partially fill the gap created by diminishing US imports from China. Thus one may argue that the slow adjustment is pareto optimal. In parallel with this analogy, large terms of trade appreciation, which is crucial to increase the US exports and decrease the US imports and as a result close down the net export deficit, in quick adjustment case, hurts the sectors in the US that uses Chinese inputs. A comparison in terms of GDP profiles over the ten years shows that slow adjustment case is preferred for both countries.

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TABLE 1 CALIBRATION

Definition	Parameter	Value
Labor share in production	α	2/3
Home input share in intermediate tradables production	v	0.72
Elasticity of intertemporal substitution bw home and foreign tradable inputs	κ	3/2
Intermediate tradable goods share in final goods production	γ	0.55
Elasticity of intertemporal substitution bw intermediate tradable and nontradable	η	3/4
Depreciation rate of capital	δ	0.1
Targeted total steady state labor of 1/3	ψ	0.35
Risk aversion parameter	σ	2
Discount factor for households	β	1/1.04
Targeted the U.S. size as 3 times of China at time $t = 1$	$\frac{\theta_{U,T}}{\theta_{C,T}}$	6
Targeted the U.S. size as 3 times of China at time $t = 1$	$\frac{\theta_{U,N}}{\theta_{C,N}}$	6
Targeted net exports surplus over GDP of 5.5% for China at time $t = 1$	B_C	-0.8
Adjustment cost parameter for capital	κ	0.00074
Adjustment cost parameter for bonds	Ω	0.0001

TABLE 2: SCENARIO 1 (SLOW ADJUSTMENT) PARAMETERS

Parameter in China	$t = 1$	$t = 2$	$t = 3$	$t = 4$	$t = 5$	$t = 6$	$t = 7$	$t = 8$	$t = 9$	$t = 10$
Tradable Technology $\theta_{C,T,t}$	1.000	1.054	1.111	1.171	1.235	1.301	1.372	1.446	1.524	1.606
Nontradable Technology $\theta_{N,T,t}$	1.000	1.027	1.054	1.082	1.111	1.141	1.171	1.202	1.235	1.267
Tradable Share in China v_C	0.550	0.539	0.528	0.517	0.506	0.494	0.483	0.472	0.461	0.450

TABLE 3: SCENARIO 2 (QUICK ADJUSTMENT) PARAMETERS

Parameter in China	$t = 1$	$t = 2$	$t = 3$	$t = 4$	$t = 5$	$t = 6$	$t = 7$	$t = 8$	$t = 9$	$t = 10$
Tradable Technology $\theta_{C,T,t}$	1.000	1.031	1.063	1.096	1.130	1.164	1.200	1.238	1.276	1.315
Nontradable Technology $\theta_{N,T,t}$	1.000	1.015	1.031	1.047	1.063	1.079	1.096	1.112	1.130	1.147
Tradable Share in China v_C	0.550	0.539	0.528	0.517	0.506	0.494	0.483	0.472	0.461	0.450
Net Exports in China $nx_{C,t}$	5.50	3.95	2.52	1.21	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 4: ROBUSTNESS WITH RESPECT TO η

Speed of Adjustment	Elasticity of substitution			
	Between Intermediate Tradables and Nontradables η			
	0.75		0.25	
	Slow	Quick	Slow	Quick
	% Change from $t = 1$ to $t = 10$			
Terms of Trade	-16.57	5.60	-8.22	24.49
Real Exchange Rate	5.73	18.35	10.57	27.69
US GDP	2.62	-0.94	1.22	-3.13
Chinese GDP	46.92	26.93	31.68	9.21

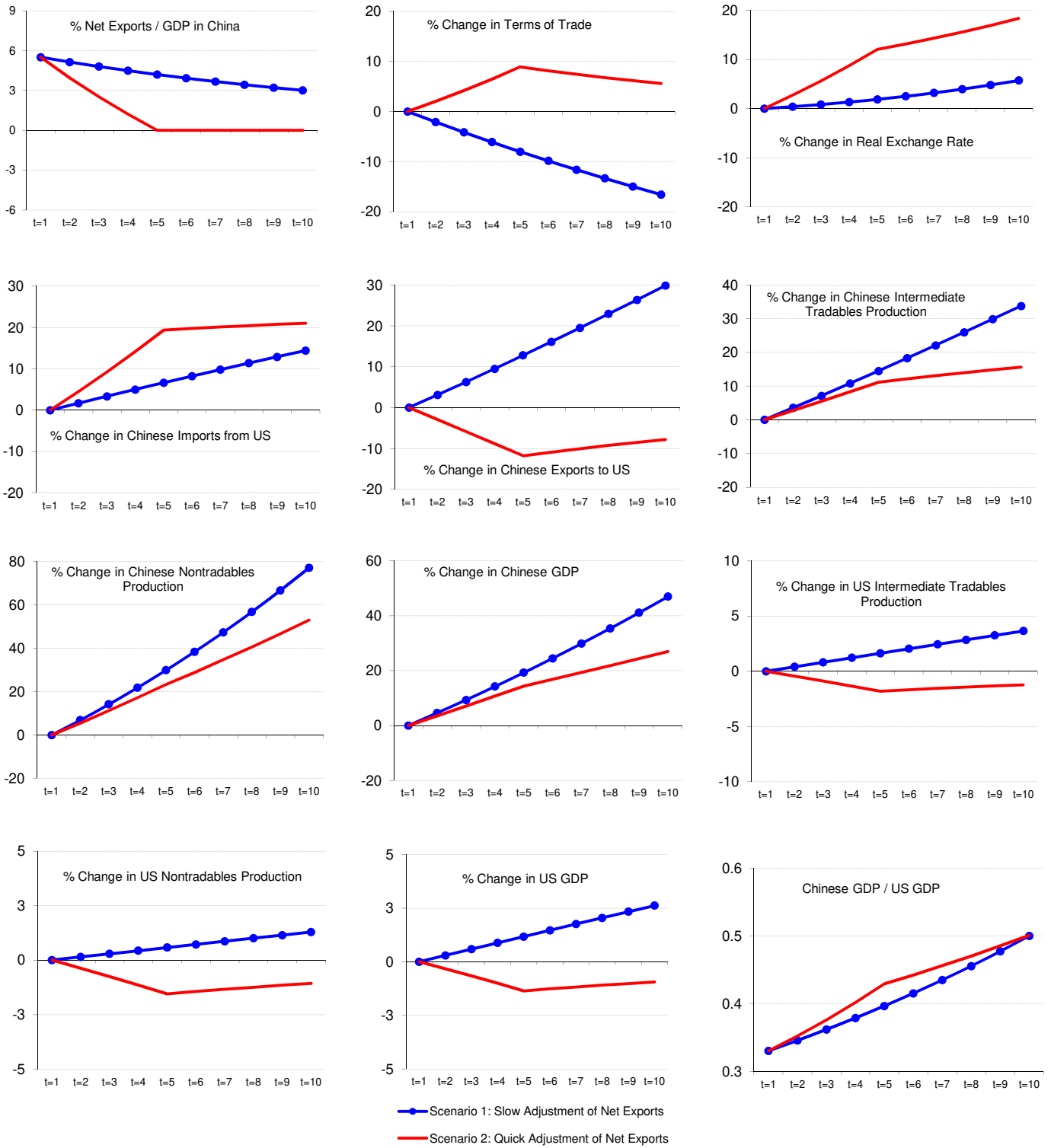


Figure 5: Steady State Simulations of Two Adjustment Scenarios

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