Real Exchange Rates in a Model of Structural Change: Applications to the Real Yen-Dollar and Chinese RMB-Dollar Exchange Rates

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ABSTRACT

We tackle the important issue of what the appropriate trends in the real Yen-Dollar and RMB-Dollar are over time. Over the long-run, the real yen has been appreciating against the U.S. dollar; while the real RMB-dollar rate has been depreciating (until 1999). In this paper, we build a macroeconomic-trade model of Japan-U.S. trade on the one hand, and China-U.S. trade on the other. Our model is essentially a general equilibrium extension of the Balassa-Samuelson effect. We show that these long-run trends in the real yen-dollar and RMB-dollar rates in the data can be justified by our model.

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1 Introduction

The appropriate levels of the yen-dollar and the RMB-dollar exchange rates are controversial topics. Since the late-1980s, the Japanese yen has appreciated rapidly against the U.S. dollar, leading to declines in Japanese corporate profits. The RMB is often alleged to be "undervalued" against the U.S. dollar, giving Chinese exporters unfair advantages in U.S. markets (Williamson, 2008).

In this paper, we tackle the question of what the appropriate paths of the real yen-dollar and RMB-dollar exchange rates are over time. Our benchmark is widely accepted in the international finance literature as a very long-term benchmark for the real exchange rate: the Balassa-Samuelson model. The Balassa-Samuelson effect is the tendency of countries with higher productivity in tradeables compared with non-tradeables to have higher price levels, and therefore an appreciating exchange rate.[1] Obstfeld and Rogoff (1996, p. 213) show in a simple example that if the productivity growth advantage in tradeables for the U.S.(vis-a-vis its trading partner) is greater than the productivity growth advantage in non-tradeables, the U.S. price index will be appreciating relative to the foreign price index, so that the real dollar exchange rate would be appreciating over time.[2]

Here we develop a macroeconomic-trade model of the very long-run yen-dollar and RMB-dollar real exchange rates, in which we take into account the shifts in production and trade between Japan and the U.S. and China and the U.S. To understand how the changes in the yen-dollar and RMB-dollar real exchange rates relates to difference in Japan-U.S. and China-U.S labor productivities, we build a two-country, three-sector (agriculture, manufacturing, and services) macroeconomic-trade model of Japan and the U.S. on the one hand, and China and the U.S. on the other hand. We treat agricultural and manufacturing goods as tradeable, and services as nontradeable. We calibrate our model to the data of each country in 1995, so that the degree of tradeability (or home bias), and other consumption and production parameters are calculated from the data. Trade is Ricardian, and the driving forces of our model are the productivities in each of the three sectors in both countries. Given these differential sectoral productivites and consumption and production parameters, trade in agriculture and in manufacturing, and the employment shares in each of the three sectors respond endogenously.

[1] This model has received widespread empirical support for a sample of industrialized postwar economies. For example, while Japan is more productive than the U.S. in manufacturers, the U.S. is far more productive than Japan in services. This has led to a rapid appreciation of the yen-dollar real exchange rate over time.

[2] The idea behind the Balassa-Samuelson model is that if the gap in tradeables and non-tradeables productivity growth is higher in the U.S. than say, the U.K., then non-tradeables prices in the U.S. will be rising faster than non-tradeable prices in the U.K. , although tradeable prices in the two countries are equated by free trade. Therefore, the weighted average of tradeables and non-tradeables–the price index–will be rising faster in the U.S. than in the U.K. The real U.S. dollar-U.K. pound exchange rate will be appreciating.

The real exchange rate computed from our model is an equilibrium or long-run benchmark in the following sense. When the actual real exchange rate is equal to the real exchange rate as simulated by our model, firms are not making excessively expansive or diminished sales or profits. Suppose that some shock, say, a rapid expansion in the money supply in Japan raises Japanese non-tradeable prices and appreciates the Japanese real exchange rate, and the Japanese real exchange rate departs from the equilibrium simulated by our model. Then the appreciation of the Japanese real exchange rate makes Japanese industries uncompetitive against U.S. industries. Japanese industries will run losses, and will lose employment.

This competitive discrepancy should be adjusted over time through changes in relative Japan-U.S. wages, capital costs, and differential rates of technical progress. However, empirically, the speed at which the real exchange rate reaches equilibrium parity is very slow. According to Froot and Rogoff (1995), standard estimates of the real exchange half-life are in the range of two to five years. Eventually, however, after 10, 15, or 20 years, absent further shocks, the actual Japanese real exchange rate should return to the equlibrium real exchange rate simulated by our model. The main finding of our paper is that our model explains well, the long-run trend behaviors of the real yen-dollar and RMB-dollar exchange rates.

In addition to simulating the long-run trends in the equilibrium real exchange rates, our model allows us to capture the large structural changes in employment that Japan and China are undergoing. In Japan, there is de-industrialization (or the shift of labor out of manufacturing and into services) and in China, there is industrialization (or the shift of labor out of agriculture and into manufacturing). In today's most advanced economies, the share of industrial employment has been declining for more than three decades. For example, the industrial employment share fell from 47 percent to 37 percent, while the services employment share increased from 44 percent to about 60 percent from 1977 to 2010 in Japan. With regards to industrialization, the substantial and permanent shift out of labor from agriculture into non-agriculture has been observed as a prominent feature of economic development. In China, the agricultural employment share fell from over 70 percent to under 40 percent from 1980 to 2010.

A key assumption in our model is that there is no capital accumulation. This reduces the analysis of our model to only static or of balanced growth paths, simplifying our analysis.[3] To the extent that the motivation of our paper is to understand the very long-run trends in the real exchange rate and not the direction of capital flows, our simplication of no capital accumulation appears reasonable.[4]

[3] The Appendix shows that a balanced growth path exists for our model.

[4] It is certainly true that labor productivity is a combination of total factor productivity and the capital labor ratio. If the production function is Cobb-Douglas, given our production function, Y=θL below, labor productivity is $\theta = A^{1/\alpha}(r/\alpha)^{\alpha/(1-\alpha)}$, where α is the capital share, A is total factor productivity, and r is the real interest rate, which is related to the capital labor ratio.

Thus, if Japan and China have different rates of capital accumulation, part of the higher labor productivity growth in China may be due to more rapid capital accumulation in China.

2 Literature Review

Ours is one of the first papers to focus on the real exchange rate in a model of structural transformation. Dekle, Eaton, and Kortum (2008) examine equilibrium exchange rates across multiple countries, but they do not examine their model's implications for the structural transformations of China and the U.S. Dekle and Fukao (2011) examine the real exchange rate between Japan and the U.S. and finds that the Balassa-Samuelson effect is observed. Ungor (2012), Obstfeld and Rogoff (1996, Ch. 4) and Matsuyama (2009), Stefanski (2011), Teignier (2011), and Yi and Zhang (2011) examine the de-industrialization hypothesis (or the movement of labor out of manufacturing) in the industrialized economies using a trade model, but do not examine the implications of their model for the real exchange rate. Asea and Mendoza (1994) and De Gregorio, Giovannini, and Wolf (1994) provide careful econometric studies of the real exchange rate and the Balassa-Samuelson effect.

Compared to our long- to very long-run analysis of real exchange rates, other papers are more interested in real exchange rates in the shorter runs. For example, Lane (2011) is concerned with more medium-run movements. In the medium-run, large creditors such as China or Japan, for example, experience an appreciation of their real exchange rate, as net investment inflows lead to an excess of domestic absorption relative to domestic production (the transfer effect). In our very long-run model, trade is balanced and there is no transfer effect. Obstfeld (2011) characterizes real exchange rates from the short- to the long-runs, and depicts how business cycles and monetary policies can change real exchange rates, and cause the short-run real exchange rate to deviate from its long-run value. He shows that the Balassa-Samuelson effect appears to hold in the long- to very long-runs, although empirically it may take more than 20 years for the real exchange rate to revert to its equlibrium value.

3 Model

We consider a 2-country, 3-sector model, where time is discrete and indexed by t= 0, 1, ...infinity. There is a measure 1 of identical, infinitely lived households endowed with 1 unit of productive time each period in each country. Households have preferences defined over 3 sectors. Sector 1 is the agricultural sector, sector 2 is services, and sector 3 is manufacturing. The agricultural and manufacturing sectors are traded. Labor is the only factor of production. Different goods in different countries are produced with different (labor) productivities. This "Ricardian" feature of the model and the degree of substitutability in preferences between home and foreign produced units of each good endogenously determine a country's equilibrium pattern of production and trade.

By admitting that our model–and concept of the real exchange rate–applies to only to long-run steady-state paths, we abstract from the complicated dynamics arising from the accumulation of capital.

3.1 Agents and Preferences

There is a representative agent in each country i, where i=1 is Japan or China, and i=2 is the U.S., who consumes all three types of goods j (in the three sectors) and works. The agent in each country is endowed with 1 unit of (paid) market time in every period, and allocates his time across alternative employment activities in the domestic country. The model is effectively a sequence of static resource allocation problems. To ease notation in what follows, we suppress time subcripts. Consumption is the only determinant of the instantaneous utility function, which is given by:

$$\mathrm{U}^i = (\gamma_1^i (C_1^i)^{(\delta-1)/\delta} + \gamma_2^i (C_2^i)^{(\delta-1)/\delta} + \gamma_3^i (C_3^i)^{(\delta-1)/\delta})^{(\delta-1)/\delta} \ \textit{where} \quad i = 1, 2.$$

Here C_1^i, C_2^i are determined by the Armington Aggregators, shown below, and C_3^i are the non-traded goods.

$$C_j^i = [\mu_j^i (C_{j1}^i)^{(\varepsilon-1)/\varepsilon} + (1-\mu_j^i)(C_{j2}^i)^{(\varepsilon-1)/\varepsilon}]^{\epsilon/(\epsilon-1)} \quad \textit{where} \quad j = 1, 2$$

C_{j1}^i, and C_{j2}^i refer to the consumption of good j by country i produced in country 1 and country 2, respectively.

Parameter δ is the (constant) elasticity of substitution between the different goods. The utility weights γ_j^i influence how consumption expediture is allocated across goods in each country. We use the Armington assumption: goods from different countries are imperfect substitutes; thus, demand for products is distinguished by place of production. In other words, foreign goods enter the economy as imperfect substitutes for domestic goods. Parameter ε is the constant elasticity of substitution (Armington elasticity) between domestically produced and imported goods.The parameter of bias in preferences towards the goods produced in country 1 is μ_j^i,whereas $(1-\mu_j^i)$ represents the parameter of bias in preference towards goods produced in country 2.

3.2 Production

There is a continuum of firms producing each good. Firms behave competitively, taking prices of the production of goods and the factor of production as given. Each good is produced using one factor of production, labor, in linear technology:

$$Y_j^i = A_j^i N_j^i \qquad \textit{where} \qquad i = 1, 2 \quad j = 1, 2, 3$$

The problem confronted by sector j in country i is the problem of maximizing profits, subject to the production technology:

$$Max \;\; p_j^i Y_j^i - w^i N_j^i \qquad where \;\; i = 1,2 \quad j = 1,2,3$$

$$s.t. \quad Y_j^i = A_j^i N_j^i$$

where $p_{i,j,t}$ is the price of the good j in country i at time t. The first-oder conditions for the producers' problem imply that the quantity of each good j produced and the quantity of the factors hired in the industry satisfy, in equilibrium:

$$p_j^i = w^i / A_j^i \qquad where \;\; i = 1,2 \quad j = 1,2,3$$

3.3 Resource Constraints

National income (output) in country i is the monetary value of outputs from each sector and is given by:

$$Y^i = p_1^i Y_1^i + p_2^i Y_2^i + p_3^i Y_3^i = w^i * (N_1^i + N_2^i + N_3^i) = w^i \qquad i = 1,2$$

Resource constraints for total employment in each country i:

$$N_1^i + N_2^i + N_3^i = 1 \qquad i = 1,2$$

Resource constraints for goods produced in traded sectors in each country i:

$$Y_1^i = C_{1,1}^i + C_{1,2}^i \qquad i = 1,2$$

$$Y_2^i = C_{2,1}^i + C_{2,2}^i \qquad i = 1,2$$

Resource constraints for goods produced in non-traded sectors in country i:

$$Y_3^i = C_3^i \qquad i = 1,2$$

Trade is balanced:

$$p_1^1 C_{1,1}^2 + p_2^1 C_{2,1}^2 = p_1^2 C_{1,2}^1 + p_2^2 C_{2,2}^1$$

3.4 Competitive Equilibrium

A competitive equilibrium consists of consumption decisions, labor allocations, sectoral output decisions, and prices such that given prices, the firm's allocations solve its profit maximization problem, the consumer's problem, and all product and labor markets in both countries clear.

3.5 The Real Exchange Rate

The bilateral real exchange rate at any date between country 1 and country 2 is given by:

$$RER^{1,2,t} = \frac{P_t^2}{P_t^1} \quad i = 1, 2.$$

The aggregate price index in country i is given by:

$$P_t^i = \frac{p_{1,t}^i Y_{1,t}^i + p_{2,t}^i Y_{2,t}^i + p_{3,t}^i Y_{3,t}^i}{Y_{1,t}^i + Y_{2,t}^i + Y_{3,t}^i} \qquad i = 1, 2.$$

3.6 Calibration

Exogenous Time Series.

$A_{j,t}^i$: We feed the sectoral productivity figures measured in the data for the sample period as follows:

$$A_{1,t}^i = \frac{Y_{1,t}^i}{L_{1,t}^i} \qquad i = 1, 2$$

For Japan and the U.S., sectoral output and labor data are from *EU KLEMS*. In China, the sectoral output and labor data are from various issues of the *China Statistical Yearbook.*

The three sectoral productivities in each of the three countries are depicted in Figures 1(a), (b), and (c). Figure 1(a) depicts sectoral labor productivities in Japan. Labor productivity in manufacturing grew the fastest, and labor productivity in services lagged in most years. While Japanese agricultural productivity growth is relatively low, less than 7 percent of Japanese labor work in the agricultural sector so that productivity growth there has little impact on aggregate variables such as the real exchange rate. Figure 1(b) depicts productivities in the U.S. While productivity in U.S. services is not high, the gap in productivity between manufacturing and services is smaller in the U.S. than in Japan, leading to the gradual appreciation of the yen against the dollar.

Figure 1(c) depicts sectoral labor productivities in China. What is remarkable is the extremely high growth in manufacturing productivity in China. While productivity growth in services is reasonable, the gap in productivity growth between manufacturing and services is higher in China than in the U.S., implying that the RMB should be appreciating against the dollar in real terms in the long-run.

This reasoning, however, ignores the large and important role of agriculture in China. Between 1985 and 2010, agriculture on average employed more than 50 percent of the Chinese labor force. If China's agricultural sector is added to the country's manufacturing sector and both are treated as the tradeables sector, then the gap in tradeables productivity and non-tradeables (services) productivity in China will sharply decline, and the real RMB may no longer be appreciating against the dollar.

Parameters.

We set the parameters to the intital year (1995) to match certain targets in production and consumption. In all three countries, we set the elasticity of substitution between two sectors as $\delta = 0.50$. In all three countries, we set the elasticity of substitution between home and foreign goods for both agricultural and industrial goods (the Armington elasticity) initially as $\epsilon = 1.5$. It is common in many applied macroeconomic models to choose values of this elasticity of substitution between 1 and 1.5 (Bodenstein, 2010).

Simonovska and Waugh (2011), however, have recently estimated Armington elasticities as $\epsilon = 2.5$ or higher. Thus, as a robustness check, we performed simulations for $\epsilon = 2.5$ and $\epsilon = 4.0$, and found that the simulated patterns for the real exchange rates are robust to these different values of the Armington elasticity.

Since our model is bilateral, we calibrate the data on bilateral data, first on Japanese and U.S. data, and second on Chinese and U.S. data. The home bias parameters will thus differ, depending on which two country pairs the data are calibrated. Since the pattern of trade differs between Japan and the U.S. on the one hand and China and the U.S. on the other, the calibrated home bias parameters differ between the two bilateral pairs of trading countries.

Given ϵ, the home consumption bias parameters, μ, are calibrated to match the initial ratios of sectoral domestic consumption to sectoral imports scaled by the sectoral terms-of-trade as follows:

$$\frac{\mu_1}{(1-\mu_1)} = \frac{C_1^1}{C_1^2}\left(\frac{p_1^1}{p_1^2}\right)^{\epsilon}$$

$$\frac{\mu_2}{(1-\mu_2)} = \frac{C_2^1}{C_2^2}\left(\frac{p_2^1}{p_2^2}\right)^{\varepsilon}$$

Finally, $\gamma' s$ are given by:

$$\frac{\gamma_1^i}{\gamma_2^i} = \left(\frac{\mu_1^i}{\mu_2^i}\right)^{\frac{-\delta}{\varepsilon}} \left(\frac{p_1^i}{p_2^i}\right)^{\delta} \left(\frac{C_{11}^i}{C_{12}^i}\right)^{\frac{\delta}{\varepsilon}} \left(\frac{C_1^i}{C_2^i}\right)^{\frac{\varepsilon-\delta}{\varepsilon}} \qquad i = 1, 2$$

$$\frac{\gamma_1^i}{\gamma_3^i} = \left(\mu_1^i\right)^{\frac{-\delta}{\varepsilon}} \left(p_1^i\right)^{\delta} \left(C_{11}^i\right)^{\frac{\delta}{\varepsilon}} \left(C_1^i\right)^{\frac{\varepsilon-\delta}{\varepsilon}} \left(C_3^i\right)^{-1} \qquad i = 1, 2$$

For Japan, sectoral consumption data are from the *Annual Report on the National Accounts.* For China, sectoral consumption data are from the *China Statistical Yearbook*. For the U.S. sectoral consumption data are from the *Statistical Abstracts*. For all three countries, sectoral trade, exports and imports, and terms of trade data are from *UN Comtrade* data.

As a result of this calibration procedure, $\gamma_1, \gamma_{2,} \gamma_3$ the utility weights on agricultural, manufactured, and service goods were calibrated as 0.33 for all three goods (in the two countries); μ_1, μ_2 the home bias parameters for agricultural and manufactured goods were calibrated as 0.45 for the country pair, Japan and the U.S.; and 0.7 for the country pair, China and the U.S. Most importantly, the results of the calibration exercise show that agricultural goods are as "tradeable" as manufactured goods at the level of aggregation of our interest.

In this paper, we are mainly concerned with the long-run trends in the real exchange rates, not the actual levels of the the real exchange rates. Still in our graphs, we will have to choose a date when the actual real exchange rate is in equilibrium according to some criteria (other than the Balassa-Samuelson). We will fix the model simulated real exchange rates as equal to the actual real exchange rate at the date when two criteria are satisfied. Our first criterion is to choose the real exhange rate that sets the trade balance equal to zero. Our second criterion is to choose the date when the exchange rate satisfies the "Purchasing-Power Parity" condition.

For the Japan-U.S. pair, using the two criteria above, we find that the acual yen-dollar real exchange rate was in equilibrium around 1980. Between 1979 and 1980, Japan's trade balance shifted from positive to negative and was nearly zero. Also, the PPP exchange rate estimated by Summers and Heston (2012) was 226 and the actual nominal exchange rate averaged about 226 in 1980.

For the China-U.S. pair, using the two criteria above, we find that the actual RMB-dollar real exchange rate was in equilibrium around 1989. China's trade balance was nearly zero, and the RMB-dollar real exchange rate was close to the purchasing-power rate in 1989 (according to Summers and Heston (2012)).

Preliminary simulations showed that the baseline model above (of Section 3) misses capturing the actual trends in the agricultural employment share in China and the services employment shares in Japan and in China. To better fit the actual employment shares in agriculture and services in China and services in Japan, we modify our model utility functions to include "subsistence agricultural consumption" in China and "home production of services" in China and in Japan.

$$U^1 = (\gamma_1^1 (C_1^1 - c_1^1)^{(\delta-1)/\delta} + \gamma_2^1 (C_2^1)^{(\delta-1)/\delta} + \gamma_3^1 (C_3^1 + c_3^1)^{(\delta-1)/\delta})^{(\delta-1)/\delta},$$

where in Japan, $c_1^1 = 0$.

Subsistence food (agricultural goods) consumption introduces non-homotheticity in the household utility function. With non-homotheticity, as income rises, more income will be spent on consuming non-agricultural goods, leading to an increase in demand for non-agricultural goods, and a larger shift in labor out of agriculture into non-agriculture.

Similarly, if there is say, home production of services, such as household work, as income increases there is relatively more demand for the market procurement of that service, such as the hiring of maids to do the household work. Services employment should grow faster with rising income and home production. We choose c_1^1 , and c_3^1 to better fit the trends in the agricultural and services employment shares in China; and c_3^1 to better fit the trend in services employment in Japan.

We assume that home production of services comes from leisure time, and does not affect the total quantity of market (paid) work in the three sectors, which is fixed at unity.

4 Results

4.1 Baseline Simulations for the Japan and the U.S. Pair

Figure 2 depicts the Japan-U.S. Real Exchange Rate in the data (solid line) and simulated from the model (dashed line)[5]. As it is well known, after the September 1985 Plaza Accord meeting, the yen-dollar nominal exchange rate steadily appreciated, momentarily reaching below 90 yen per dollar in early 1995. Subsequently, the yen weakened to as much as 130, although it has mostly been in the 110-120 range in the 2000s. However, after the Lehman shock in the fall of 2008, the nominal yen-dollar rate started to appreciate, reaching about 87 yen to the dollar in 2010.

[5] In the data, the real exchange rate is defined as the ratio of the weighted GDP deflators in the two countries in terms of dollars. To convert the Japanese GDP deflator into dollars, we use the nominal yen-dollar exchange rate. In the model, the real exchange rate is defined as the ratio of the weighted averages of the prices in the agricultural, manufacturing, and the services sectors in Japan and the U.S.

The dashed line, the model simulated real exchange rate, generally tracks the data well in the very long run. Specifically, we observe the Balassa-Samuelson effect–an appreciation of the Japanese real exchange rate over the long-run. Despite the common impression that during Japan's "lost decade" in the 1990s and in the early 2000s, Japanese productivity growth was low, Japanese productivity growth in the tradeables sectors such as automotives and electronics were usually higher than that in the U.S., which explains the (slight) trend appreciation in the yen-dollar equilibrium real exchange rate during this time (Dekle and Fukao, 2011).

Unsurprisingly, in our model with no money and no price rigidities, we miss most of the short- and medium-run fluctuations of the real exchange rate. If we take the simulated real exchange rate series as a long-run benchmark, we find that the actual real exchange rate was "overvalued" from 1986 and extremely overvalued until 1995, at which point the actual real yen-dollar exchange rate started to depreciate. Between 2000-2005, the yen real exchange rate was relatively weak. Following the 2008-2009 global financial crisis, the real yen started to appreciate again.

We have shown that slower relative productivity growth in the services industry will tend to appreciate the real exchange rate in the long run. Many observers also tie to the faster productivity growth in tradeable goods, the decline in employment of the manufacturing sector of industrialized countries–the so-called "de-industrialization" effect. The economic reasoning is simple: with fewer workers able to produce a higher volume of manufacturers, some workers will have to switch jobs to services.

As Obstfeld and Rogoff (1996, Ch. 4) and Matsuyama (2008) point out, however, this simple reasoning does not account for the fact that demand for and thereby employment in manufacturers in a particular country may fall off, owing to the decline in their price in the global market, because of oversupply or increased global competition. The change in manufacturing generally depends in a complicated way on sectoral demand and supply elasticities, both domestic and abroad. Our model allows us to solve for these complicated general equilibrium effects of sectoral productivity and trade on sectoral employment shares. We compare our model simulations with what actually happened to the employment shares in the three sectors in Japan 1980 and 2010

Figures 3 (a), (b), and (c) depict the trends in the labor shares for the agricultural, manufacturing, and services sectors in Japan in the data (solid lines) and in the model (dashed lines). The share of Japanese employment in agriculture dropped from 8.5 percent to about 3 percent from 1980 to 2010. The model overpredicts the agricultural share. This is because in a model of U.S.-Japan bilateral trade, Japan's trade with large agricultural exporters such as Brazil and Thailand are excluded. Agricultural imports from these countries should serve to depress Japanese agricultural employment. The model captures the "de-industrialization"–or the decline in Japan's manufacturing employment–very well, while the model predicts the sharp rise in Japanese services employment rather well.

4.1.1 Robustness Checks for the Japan-U.S. Pair.

In applied macroeconomic-trade models, the simulation results are often sensitive to values of the Armington elasticity, ε. Here we check whether our results are sensitive to raising the Armington elasticities from 1.5 to 2.5 and 4.0.

Figures 4 (a) and (b) depict the simulated equilibrium yen-dollar real exchanges rates under $\varepsilon = 2.5$ and $\varepsilon = 4.0$. It appears that the shocks to the equilibrium real exchange rates are rather insensitive to increases in the value of the Armington elasticity.

4.2 Simulations for the China and the U.S. Pair

Figure 5 depicts the long-run RMB-dollar rate in the data (solid line) from 1985 to 2010. While the trend in the Japan-U.S. real exchange rate is familiar to most audiences, the trend in the China-U.S. real exchange rate may be less familiar. We can see that from 1985 to about 1999, the RMB-dollar real exchange rate has been depreciating, despite a much higher rate of real economic growth in China compared to that in the U.S. Between 2000, the RMB-dollar rate was relatively flat, but since 2005, the RMB–dollar rate has been appreciating, in fact, quite rapidly.

The Balassa-Samuelson theory says that the secular change in the real dollar-RMB rate should depend on the "difference-in-difference" in tradeables and non-tradeables productivity growth within and between China and the U.S. Between 1985 and 2010, annualized average real labor productivity was 1.9 percent in agriculture, 3.0 percent in manufacturing, and 1.9 percent in services in the U.S.; and 4.3 percent in agriculture, 8.0 percent in manufacturing, and 5.0 percent in services in China. The gap in productivity between manufactures (tradeables) and services (non-tradeables) in the U.S. was 1.1 percent and 3.0 percent in China. Thus, given the productivity differentials, the Balassa-Samuelson theory predicts that the RMB-dollar real exchange rate should be appreciating.

The calculation above, however, ignores the important role that the size and productivity of the agricultural or primary goods sector plays in China. Agricultural or primary goods output was over 50 percent of total output in China in many of the years after 1985.[6] If we treat agricultural or primary goods as traded goods, then the "difference-in-difference" in tradeables and non-tradeables productivities between the U.S. and China drops from 1.9 percent to about -0.1 percent, predicting a rather constant or slightly depreciating RMB-dollar real exchange rate over time.[7]

[6] "Agricultural" output and employment include all primary goods output and employment, including food, raw materials, and mineral fuels.

[7] China does engage in considerable agricultural or primary goods trade. In 1985, primary goods imports were 12 percent of total Chinese imports. In 2008, primary goods imports,

In fact, that is what we find in our model simulations (Figure 5, dashed line). The equilibrium long-run real RMB-dollar real exchange is depreciating over time (dashed line). Our analysis suggests that the long-run real depreciation in the RMB-dollar exchange rate can be justified by the sectoral productivity and trade patterns between China and the U.S.

Figures 6 (a), (b), and (c) depict the trends in the Chinese sectoral labor shares. As noted, the agricutural employment share in China has been sharply decreasing, while the manufacturing and services shares have been increasing. After taking into account, Chinese subsistence agricultural consumption and home production in services, the model (dashed lines) now tracks the trends in the data (solid line) quite well.

4.2.1 Robustness Checks for the China-U.S. Pair.

Figures 7 (a) and (b) depict the simulated equilibrium RMB-dollar real exchange rates under $\varepsilon = 2.5$ and $\varepsilon = 4.0$. Again, the long-run depreciating patterns in the model simulated RMB-dollar real exchange rates appear robust to increases in the value of the Armington elasticity

5 Conclusion

This paper has shown that the Balassa-Samuelson effect explains well, the long-run trend behaviors in the yen-dollar and the RMB-dollar real exchange rates. In particular, our model can explain the puzzling long-run real depreciation (from 1989-1999) or the lack of real appreciation (from 2000 to 2005) of the RMB-dollar real exchange rate.

The proportion of the labor force in Chinese agriculture has fallen to around 30 percent in 2011, as many rural dwellers moved from the farms and into the cities. As Chinese labor leaves the farm and joins the manufacturing sector, and as continued mechanization proceeds, productivity in Chinese agriculture should continue to increase. These interrelated trends are probably responsible for the actual appreciation of the Chinese real exchange rate against the dollar since 2005. Over the next few decades, we should see continued rapid appreciation of the real Chinese currency, a pattern observed for the Japanese yen since the 1970s.

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especially raw materials and mineral fuels were 32 percent of total imports. In 1985, primary goods exports were 50 percent of China's total exports. In 2008, primary goods exports were 5 percent of China's total exports.

6 Appendix

6.1 The Balanced-Growth Path in Our Model

Given that the one period utility functions in any two countries are CES and homothetic, we can aggregate the utility functions of the two countries into a single aggregate, or "social utility" function (Gorman, 1953):

$$u(c_1^1, c_2^1, c_3^1, c_1^2, c_2^2, c_3^2) = \left(\sum_{k=1}^{6} \varpi_k c_k^{(\epsilon-1)/\epsilon}\right)^{\epsilon/\epsilon-1} \qquad (A1)$$

defined over the six goods (three in each country). ϖ_k are the consumption weights chosen by the social planner, taking into account, each country's utility and production functions, labor endowment (labor allocation in each period), and productivity growth. With this set-up, we can drop country superscripts; hence we have the right-hand side of the equation (A1) representing the world utility function.

From here, our set-up is parallel to Ngai and Pissarides (2007), who show that even with ongoing structural change, the economy's aggregate consumption-income and saving-income ratios are constant. That is, there is a world balanced growth path. Specifically, if aggregate consumption and output are:

$$c = \sum_{k=1}^{6} p_k c_k \quad and \quad y = \sum_{k=1}^{6} p_k y_k,$$

where p_k and y_k are the price and output of good k, then Ngai and Pissarides (2007) show that in every period, c/y is constant.

Ngai and Pissarides also show that in every period:

$$\frac{\Delta L_k}{L_k} - \frac{\Delta L_M}{L_M} = (1-\epsilon)\left(\frac{\Delta PROD_M}{PROD_M} - \frac{\Delta PROD_K}{PROD_K}\right) \qquad L \neq M$$

That is, if the elasticity of substitution, ϵ, is less than one, labor in the sector with the lower productivity growth will shift to the sector with the higher productivity growth. Moreover, this pattern of labor movement, or structural transformation, is consistent with a balanced growth path.

Figure 1(a).

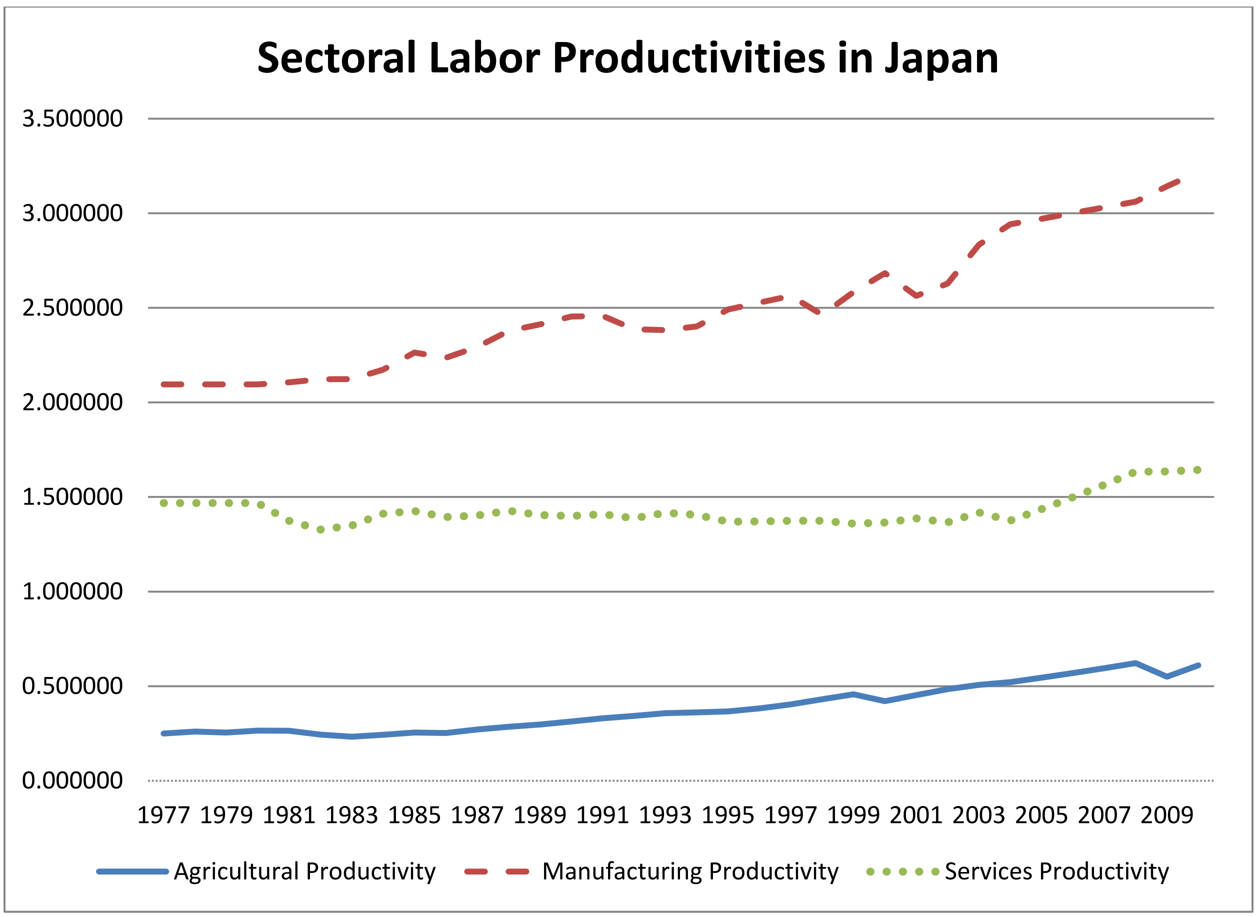
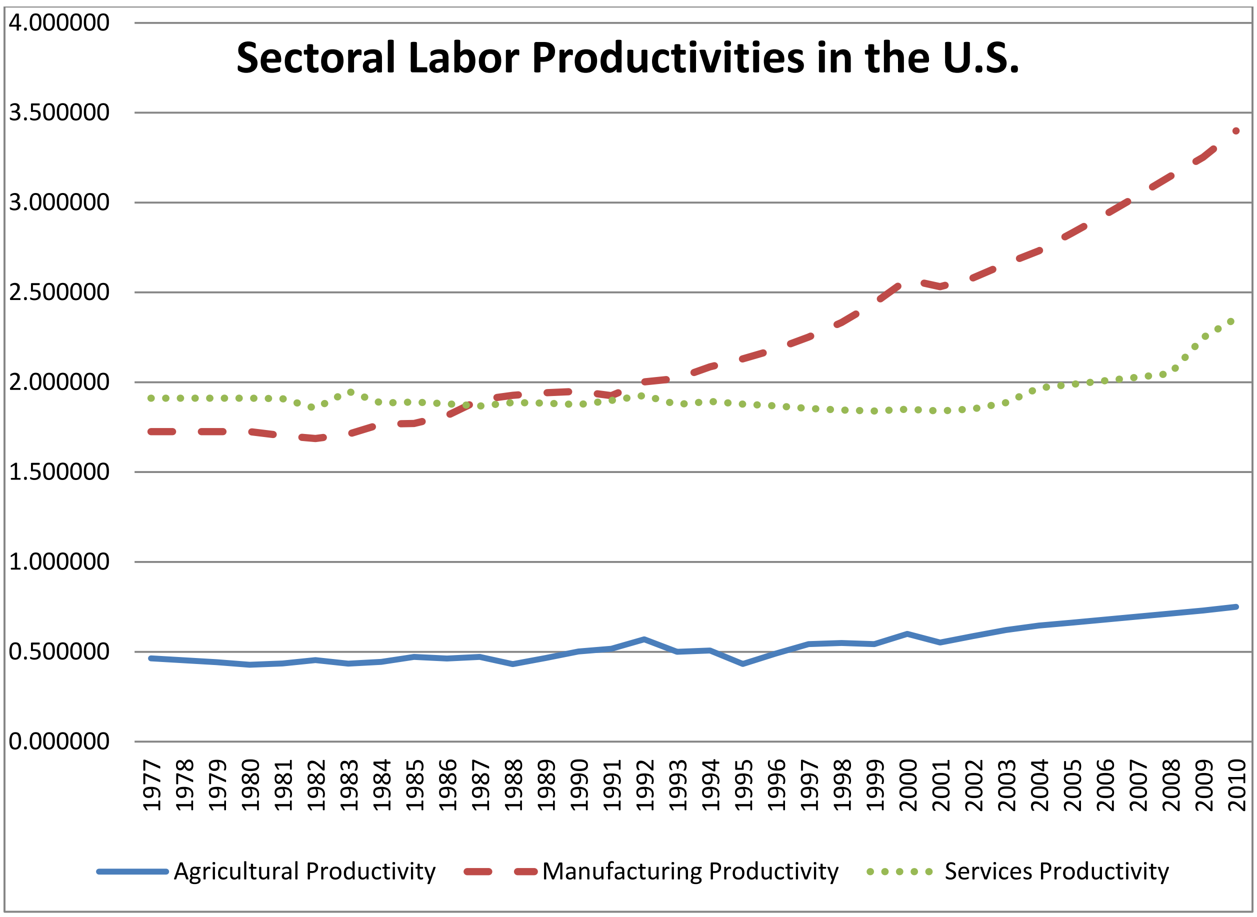
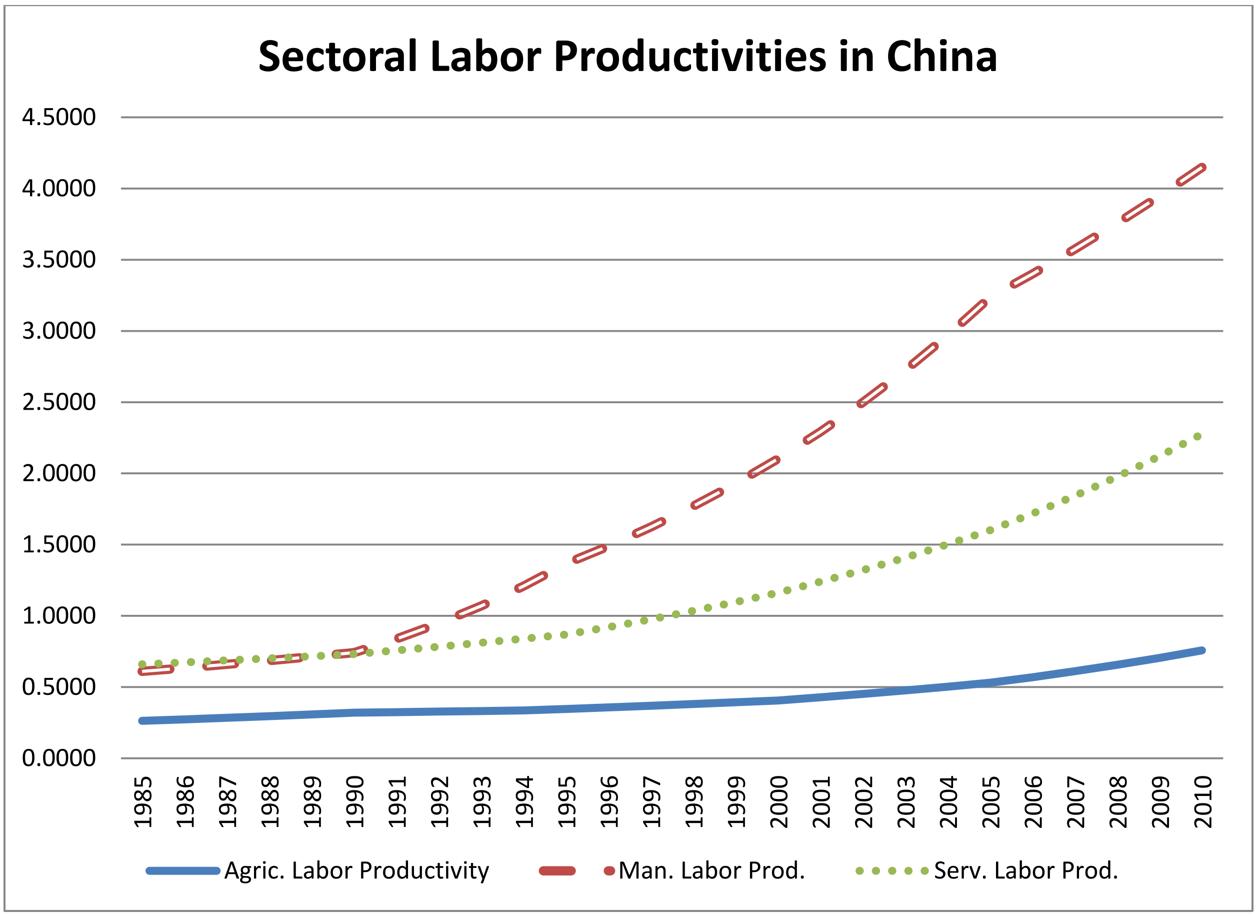

Sectoral Labor Productivities in Japan
3.500000
3.000000
2.500000
2.000000
1.500000
1.000000
0.500000
0.000000
1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009
Agricultural Productivity
Manufacturing Productivity
Services Productivity

Figure 1(b).



Sectoral Labor Productivities in the U.S.
4.000000
3.500000
3.000000
2.500000
2.000000
1.500000
1.000000
0.500000
0.000000
1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Agricultural Productivity
Manufacturing Productivity
Services Productivity

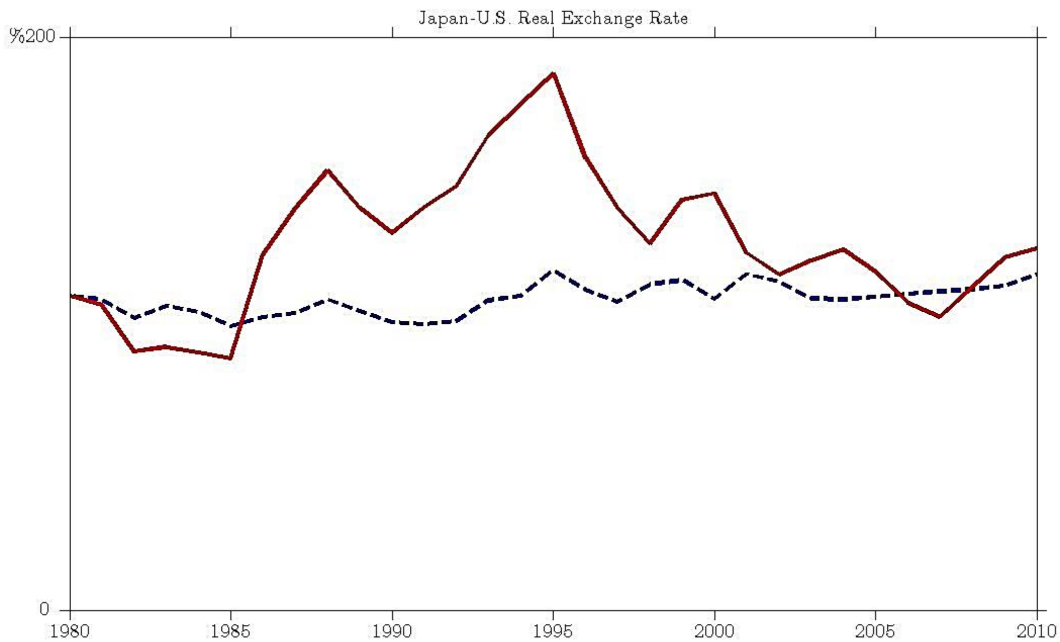
Figure 1(c).



Sectoral Labor Productivities in China
4.5000
4.0000
3.5000
3.0000
2.5000
2.0000
1.5000
1.0000
0.5000
0.0000
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Agric. Labor Productivity
Man. Labor Prod.
Serv. Labor Prod.

Figure 2.

(Armington Elasticity: 1.5)

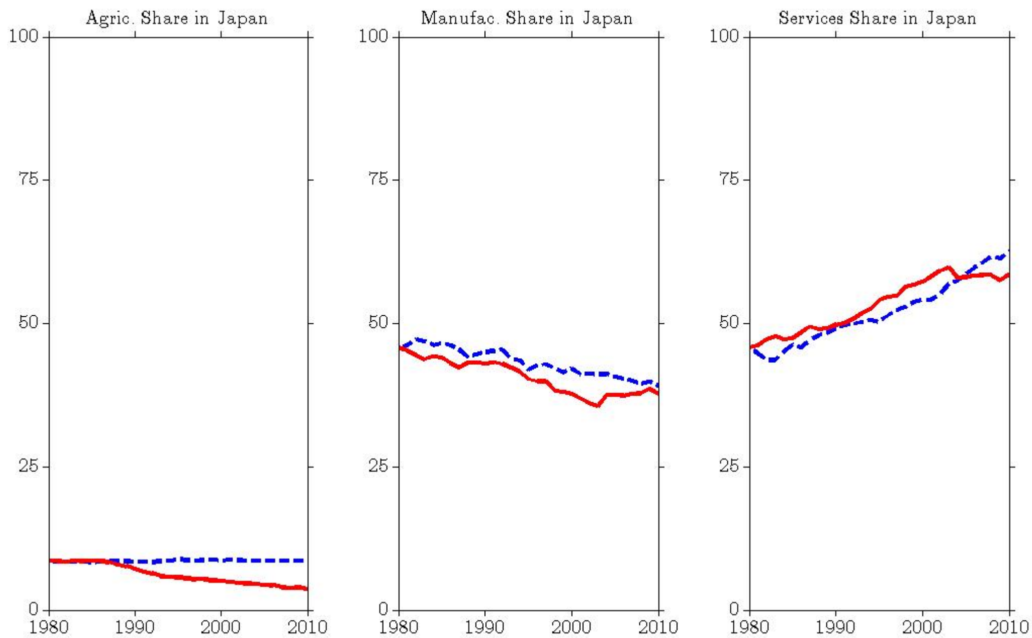


Solid: Data.

Dashed: Model Simulations.

Figures 3(a), 3(b), 3(c).

Employment Shares by Industry.

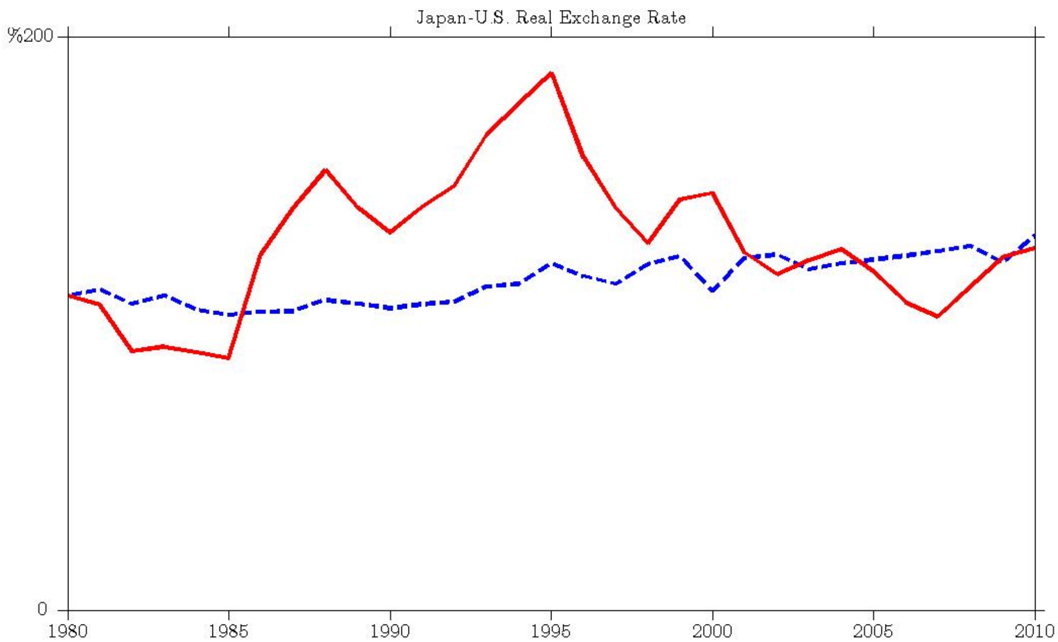


Solid: Data.

Dashed: Model Simulations.

Figure 4(a).

(Armington Elasticity: 2.5)

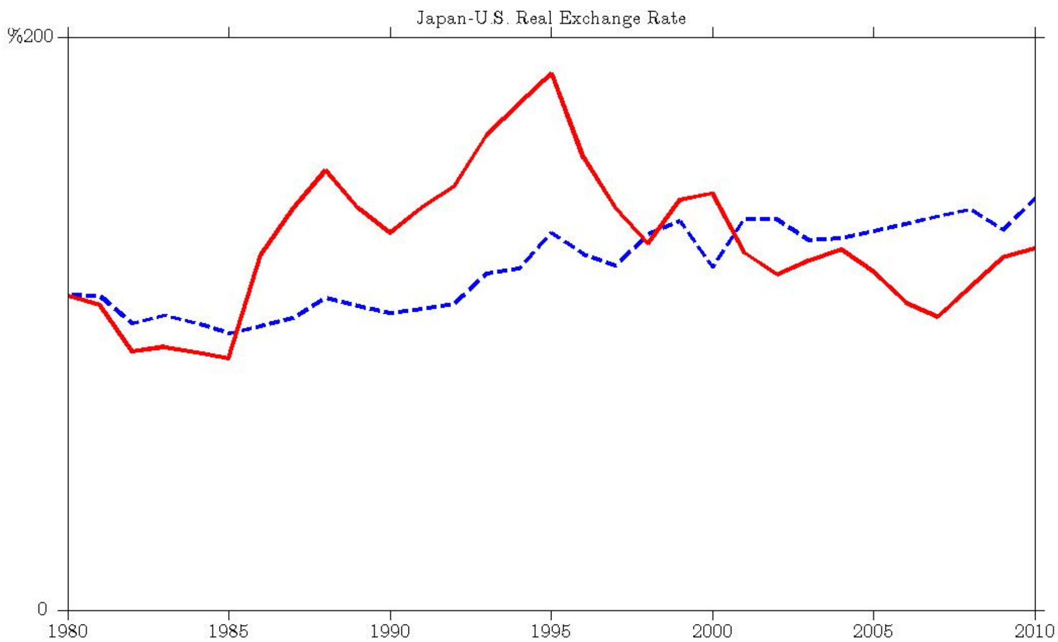


Solid: Data.

Dashed: Model Simulations.

Figure 4(b).

(Armington Elasticity: 4.0)

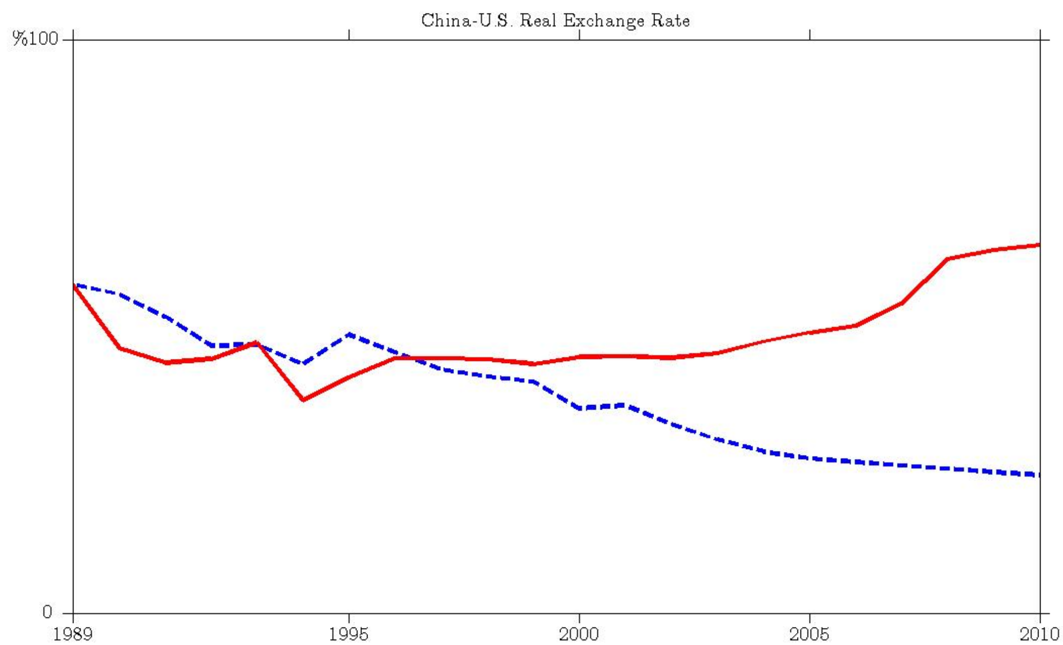


Solid: Data.

Dashed: Model Simulation.

Figure 5.

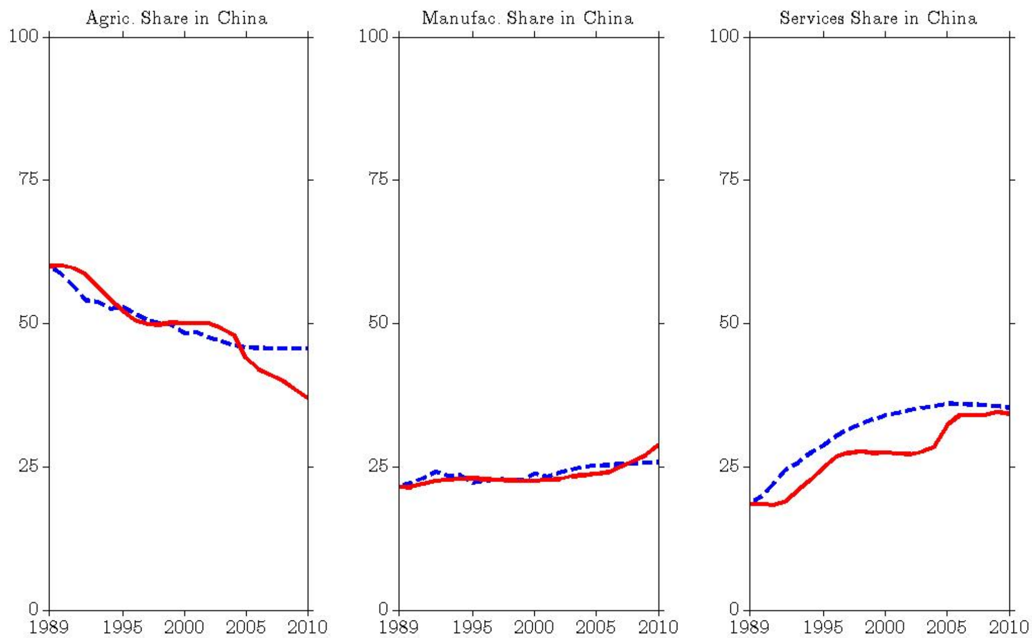
(Armington Elasticity: 1.5)



Solid: Data; Dashed: Model Simulations.

Figures 6(a), 6(b), 6(c).

Employment Shares by Industry.



Solid: Data; Dashed: Model Simulations.

Figure 7(a).

(Armington Elasticity: 2.5)

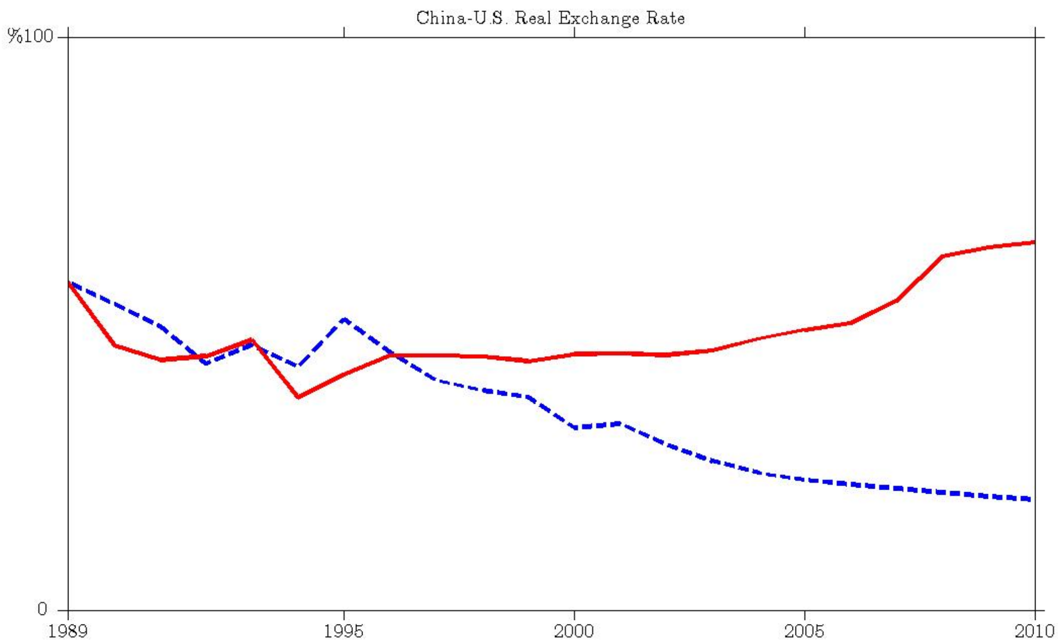
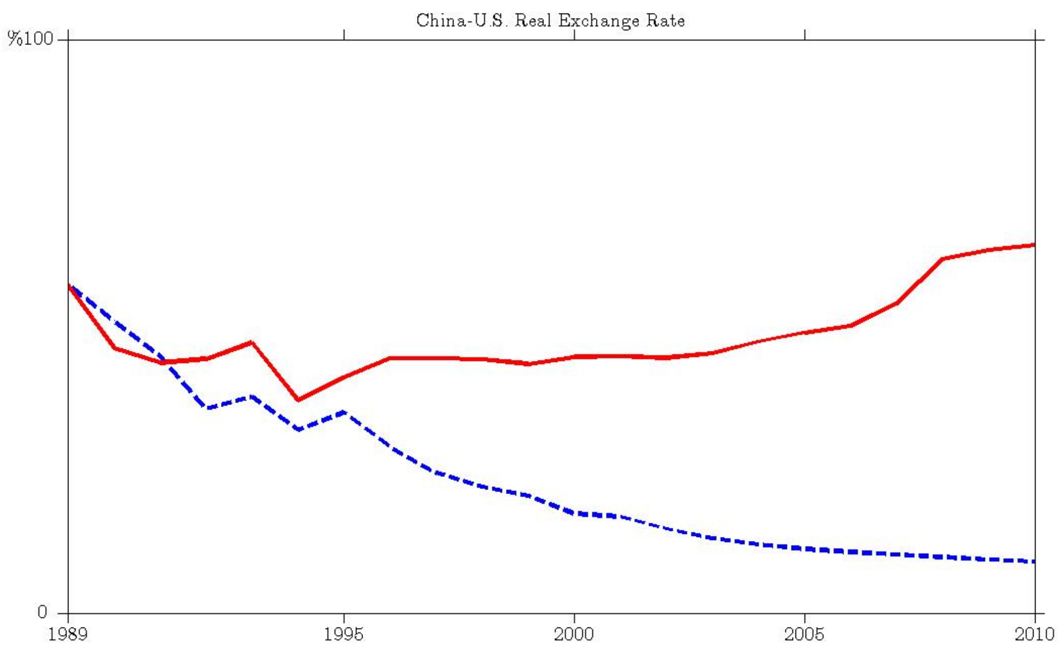


Figure 7(b).

(Armington Elasticity: 4.0)



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