Excess Labor Supply, Structural Change and Real Exchange Rate

Jiandong Ju*
Shanghai University of Economics and Finance
Justin Yifu Lin
CCER, Peking University
Qing Liu
Tsinghua University
Kang Shi
The Chinese University of Hong Kong

This Version: March 2016

Abstract

Since China joined the WTO in 2001, the Chinese economy has grown very rapidly, especially, the tradable goods sector. However, the Chinese real exchange rate did not exhibit a persistent and stable appreciation until 2005. This is a puzzling fact that is inconsistent with theories. This paper documents several stylized facts during the economic transition and argues that two features of Chinese economy may help explain the puzzling real exchange rate pattern for Chinese economy: i) the faster total factor productivity (TFP) growth in export sector compared with the import sector; ii) excess supply of unskilled labor. We construct a small open economy model with an H-O trade structure and show that, due to heterogeneous skilled labor intensity in export and import sectors, the faster TFP growth in the export sector over that in the import sector will lead to the decline of return to capital and the rise of skilled wage. Therefore, the decrease of return to capital and the persistent low unskilled wage, which is caused by the excess supply of unskilled labor, inhibit the rise in the relative price of non-tradable goods to tradable goods as well as the appreciation of real exchange rate. Furtheremore, we develop a dynamic small open economy model with multiple tradable goods sectors, and show that the model does fairly well in explaining the Chinese real exchange rate and other stylized facts in the economic transition. Finally, we demonstrate that our hypotheses are supported by cross-country evidence.

JEL classification: F3, F4

Keywords: Real Exchange Rate; Chinese Economy; Excess Labor Supply; H-O Structure

*Ju: Shanghai University of Economics and Finance, Email : ju.jiandong@shufe.edu.cn; Lin; CCER, Peking University, Beijing; Email : justinlin@ccer.pku.edu.cn; Liu: School of Economics and Management, Tsinghua University, liuqing@sem.tsinghua.edu.cn; Shi: Department of Economics, The Chinese University of Hong Kong; Email: kangshi@cuhk.edu.hk. We thank Shang-jin Wei and Michael Song for their helpful comments and discussions. We also thank the participants in the 2014 Econometric Society China Meeting, 2014 NBER-CCER Conference, 2014 Fudan Monetary Economics workshop, 2014 World Congress (Jordan), and 2015 People's Bank of China Macroeconomic Conference, as well as seminars held at Tsinghua University, Hong Kong University, and the Chinese Univeristy of Hong Kong.

1 Introduction

Since China joined the WTO in 2001, the Chinese economy has grown rapidly, especially the tradable goods sector, which expands dramatically. In the period of 2001-2007, China's annual GDP growth reached an average of 11.2% and its annual growth rate of total trade is close to 20.2%. However, the China's real exchange rate depreciated about 6.7% instead (see Figure 1 and 2). This finding is puzzling and is inconsistent with theories. According to the Balassa-Samuelson hypothesis, a positive relationship should be observed between the economic growth and the appreciation of the real exchange rate; this relationship is driven by productivity catch-up in China's tradable sectors, and the resulting rising prices in China's non-tradable sectors. Interestingly, existing literature pays little attention to the Chinese real exchange rate despite the substantial research on China's current account imbalance during that period, as conducted by scholars such as Song, Storesletten, and Zilibotti (2011), Wei and Zhang (2011), and Ju, Shi, and Wei (2013). The present study aims to fill this gap and to propose a model of real exchange rate that is consistent with China's economic transition.

First, this work presents several stylized facts regarding this fast-growing period: persistent real exchange rate depreciation, significant current account surplus, considerable migration from rural to urban areas, the sharp rise in skilled wage premium, and uneven technological progress within the tradable goods sector (see Figures 2-6). The first four facts have been well documented in literature, but the final one has not been noted yet. Since 1978, China has maintained a high growth rate of almost 10% per year, which remains miraculous for many researchers as well as policy makers. It is well documented that the technological improvement across sectors in China also follows the prevailing pattern of a fast-growing country, that is, the tradable goods sector expands more quickly than the non-tradable goods sector does. However, if we decompose the total factor productivity (TFP) growth within the tradable goods sectors, then the average TFP growth rate in the export sector is higher than that in the import sector. Using Chinese manufacturing data and Chinese custom data, we find that during the period of 2001-2006, the TFP growth rate of the export sector is significantly higher than that of import sector.

In the current study, we argue that the faster TFP growth in the export sector over that in the import sector as well as the excess supply of unskilled labor may help explain the Chinese real exchange rate and other stylized facts. We first build two static models to explain the potential depreciation of the real exchange rate during this fast-growing period. When the labor is abundant, the wage of labor will be depressed to the minimum level, and the technological improvement drives up the demand for capital. This increase in turn boost the real interest rate, thereby increasing the price of non-tradable goods. This result implies that the present transmission mechanism relies on return to capital instead of wage in the standard real exchange rate model. In such an environment, the price of non-tradable goods will not rise unless the tradable goods sector grows much faster than that of non-tradable goods if the technologies in both sectors are improving. The abundance of labor supply alters the transmission mechanism and weakens the Balassa-Samuelson effect. Moreover, we introduce the H-O trade structure and heterogenous labor (skilled vs unskilled) into the real exchange rate model. Due to the heterogeneous skilled labor intensity in the export and import sectors, the accelerated TFP growth in the export sector over that in the import sector will lead to the decline of the return to capital and the rise in skilled wage. Therefore, the decrease in return to capital and the persistently low unskilled wage, which is caused by an excess supply of unskilled labor, inhibit the rise in the price of non-tradable goods relative to tradable goods and induce the appreciation of real exchange rate.

To accounts for both current account dynamics and the real exchange rate, we develop a dynamic small open economy model with an H-O structure. We consider two tradable goods sectors with heterogeneous factor intensity (the aforementioned H-O structure). We calibrate the model and show that the model can effectively explain the dynamics of the Chinese real exchange rate and other stylized facts documented for Chinese economy during transition, such as the significant increase in skilled labor premium. In the model, the rapid TFP progress in the export sector, which is supposedly labor intensive in China, also results in capital outflow, as observed in the Chinese data. To generate the depreciation of real exchange rate, both abundant unskilled labor supply and the uneven technological progress within the tradable good sector are essential. However, a shortage of unskilled workers has often been observed since 2005 due to the rapid economic growth. This occurrence inevitably causes an increase in the unskilled wage, which in turn boosts the prices of the non-tradable goods and then facilitates the appreciation of the real exchange rate. This implies that the traditional Balassa-Samuelson (BS) mechanism also works in our model. Moreover, this mechanism disrupts the trade balance after the financial crisis. Overall, our simulation results suggest that the real exchange rate exhibits an inverted U-shape, which is the pattern observed in the Chinese data.[1]

This paper is motivated by China's experience and intends to explain the dynamics of Chinese real exchange rate. Our theory, however, may also be applied to other fast-growing developing countries given that an accelerated TFP growth in the export sector over that in the import sector is a common feature in these economies, in addition to the labor transition from the agriculture to manufacturing sectors. Using cross-country data, we also find evidence that considerable migration from rural to urban areas and the uneven growth between export and import sectors depress real exchange rate appreciation in developing countries. In this aspect, our work also contributes to the literature on real exchange rate, in which the most well-known theory is the Balassa-Samuelson effect (Balassa, 1964; and Samuelson, 1964). Our paper presents a theory to explain why this effect may fail in these fast-growing economies.

[1] Our benchmark model is simple; therefore, it can only match signs but not magnitudes. To match quantitatively with the Chinese data, we must incorporate more realistic institution features or frictions into the model.

Moreover, our study on the Balassa-Samuelson effect differs from those that emphasize the Froot-Rogoff effect, which postulates that the real exchange rate tends to rise with government consumption because government spending tends to fall disproportionately on domestic non-tradable goods and services (Froot and Rogoff, 1991). According to Rogoff (1996), there are considerable, although not unanimous, empirical supports for both the Balassa-Samuelson effect and the Froot-Rogoff effect.[2]

Our work is related to a small but growing literature that considers multiple tradable sectors with different factor intensities in a general equilibrium framework. These papers include Cunat and Maffezzoli (2004), Ju and Wei (2007), Jin (2012), Jin and Li (2012), and Ju, Shi, and Wei (2013, 2014). Nevertheless, none of the existing works in this literature explicitly studies the real exchange rate. To our best knowledge, there are few theories that accounts for Chinese real exchange rate. Most of the studies on the Chinese real exchange rate are empirical; for example, Cheung, Chinn, and Fujii (2008) examine whether or not the Chinese exchange rate is misaligned and how Chinese trade flows respond to the exchange rate as well as to economic activity. Recently, Du and Wei (2013) presented a model with competitive saving motivation to show that the rise of sex-ratio may help explain the decline of the real exchange rate in China.[3]

The rest of the paper is organized as follows. Section 2 documents the stylized facts during China's fast-growing period. Section 3 presents static small open economy models of real exchange rate to show the model mechanism. Section 4 develops a dynamic model with an H-O structure to explain both the real exchange rate and current account dynamics. Section 5 reports the numerical results. Section 6 presents cross-country empirical evidence. Section 7 concludes this study.

2 Stylized Facts during the Transition of Chinese Economy

In this section, we document a few stylized facts regarding the Chinese economy during its fast-growing period that began in 2000.

1. **No real exchange rate appreciation was observed during the fast-growing**

[2] Recently, Du, Wei, and Xie (2013) argued that transport infrastructure is an important determinant of the real exchange rate. The economic importance of the infrastructure effect is almost on par with that of the well-known Balassa-Samuelson effect and is much greater than the Froot-Rogoff effect.

[3] In our model, the structure change caused by uneven technological progress within the traded goods sector is a key to explaining the real exchange rate. We noted recently Wang, Xu, and Zhu (2013) also attemped to use structure change to explain the US-China bilateral real exchange rate in a two-country model. However, they focused on the structural changes among agriculture, manufacturing, and service sectors, unlike our work.

period

Countries with rapidly expanding economies tend to have exchange rates that appreciate quickly; this occurrence is well-known as the Balassa–Samuelson effect. Given the fact of maintaining a high growth rate over a long period in China, a persistent real appreciation should be expected. Figure 2 shows that, however, the Chinese real exchange rate did not appreciate persistently until only recent. In particular, we still do not observe real exchange rate appreciation even after China joined the WTO in 2001 and the tradable sector expanded dramatically. Instead, the real exchange rate depreciated at a rate of approximately 6.7% from 2001 to 2007. Our model described in following section provides an explanation for this puzzling fact.

2. **Significant trade balance and the rapid accumulation of foreign reserves**

   Since 2001, the Chinese economy has been increasingly integrated into the world economy during its development. The share of international trade (export plus import) in GDP rose from less than 20% in the early 1980's to almost 70% in 2007. During the process of China's integrating into the world, we observed a considerable trade imbalance that has increased rapidly, especially in recent years. As illustrated in Figure 3, the annual average of the trade imbalance increased sharply when China joined the WTO; in 2007, China's trade balance over GDP peaked at approximately 9%. Meanwhile, the country also holds huge amount of foreign reserves that consists of roughly 50% of GDP. Such a significant trade imbalance has generated a major political and economic issue between China and its trading partners; this situation has also initiated a series of policy debates and academic controversies.

3. **Considerable migration of unskilled labor from rural areas to the urban industry**

   During China's transition period, we observe the large-scale migration of unskilled labor from rural areas to the urban industry. A total of 2 million migrant workers, most of which were unskilled laborers, first migrated in 1978; this number surged up to 268 million in 2013. The mobilization of labor from rural areas provides an excess supply of unskilled labor to the industry, which in turn contributed to the persistent growth of the Chinese economy. Due to rapid economic growth, substantial reports or data have been presented regarding rising migrant wages (see Figure 4), thus implying the shortage of unskilled labor in China.[4] A few researchers, such as Cai et al. (2007), Park et al. (2007), and Wang (2008), even argue that China has presently reached the Lewis turning point.

[4]According to the survey conducted by the CSSA, in 2007, only 32% of firms could hire sufficient workers in 2007. At least one third of the firms experienced labor supply shortage, with a gap higher than 25%.

4. **Income inequality between skilled and unskilled workers**

   China's economic transition is accompanied by increasing income inequality, especially in terms of wage inequality between skilled and unskilled workers. Following Ge and Yang (2014), we use UHS data (1988-2012) to compute the skill premium. The results are reported in Figure 5, which also shows the trend of skill premium since 2000.[5] This skill premium increased considerably after China's entrance into the WTO, as widely documented in literature. However, the trend reversed in 2009; starting from this particular year, skill premium has declined rapidly from 0.474 to 0.393.

5. **Higher TFP growth in exporting sectors than in importing sectors**

   The growth rate of tradable sectors in China has remained high since 2001. If we decompose the aggregate TFP growth by sectors, the technological improvement across sectors follows the prevailing pattern of a fast-growing country, that is, the tradable goods sector grows faster than non-tradable goods sector does. Moreover, using the Chinese manufacturing data and Chinese custom data, we compute the average TFP growth rate in export and import sectors during the period of 2001-2006. Overall, the former is growing significantly faster than the latter is, as shown in Figure 6.[6]

3 Static Models

In this section, we set up two static models to reveal the main channels that we focus in this paper. To highlight the role of the two important features of China's transition, namely, the excess supply of unskilled labor and the uneven technological progress within the tradable goods sector, we begin with the standard two-sector model.

3.1 Two-sector Model with Excess Labor Supply

Consider a small open economy where the final good is a Cobb-Douglas aggregation of tradable and non-tradable goods. The aggregate price is simply given by $P = (P_T)^{\theta} (P_N)^{1-\theta}$, where P_T and P_N are the prices of tradable and non-tradable goods, respectively. In such a setting, the real exchange rate can be measured by the relative price of non-tradable to tradable goods. For simplicity, we regard the tradable goods as the numeraire, and its price

[5] Here the skilled labor includes high school and college education. We also compute the case in which skilled labor only covers only those with college education, and the obtained results are similar.

[6] Two methods (OP and ACF) are used to estimate sector-level TFP. The estimation process is detailed in Appendix A. Results are similar in both method; for simplicity, we report only the TFP estimated with the ACF method depicted in Figure 6.

is normalized to 1 so that P_N can reflect the movement of the real exchange rate. The technologies applied in the two sectors are given as follows:

$$Y_T = A_T(\frac{L_T}{1-\alpha_T})^{1-\alpha_T}(\frac{K_T}{\alpha_T})^{\alpha_T}, \tag{3.1}$$

$$Y_N = A_N(\frac{L_N}{1-\alpha_N})^{1-\alpha_N}(\frac{K_N}{\alpha_N})^{\alpha_N}, \tag{3.2}$$

where L_i denotes the labor used in sector i, K_i is the capital used in sector i, and A_i is the TFP in sector i. $i = T, N$ (T refers to the tradable goods sector and N to the non-tradable goods sector). In accordance with the literature, we assume that $\alpha_T > \alpha_N$, that is, that the non-tradable goods sector is more labor intensive than the tradable goods sector is.

We first consider a benchmark model where capital is mobile internationally and labor is mobile only domestically. Therefore, in a competitive equilibrium, we obtain the following:

$$1 = \frac{(W)^{1-\alpha_T} r^{\alpha_T}}{A_T}, \tag{3.3}$$

$$P_N = \frac{(W)^{1-\alpha_N} r^{\alpha_N}}{A_N}, \tag{3.4}$$

where r is the return to capital and w is the wage of labor. Given that capital is perfectly mobile across borders, we have $r = r^*$. This result implies the following:

$$P_N = \phi_1 \frac{(A_T)^{\frac{1-\alpha_N}{1-\alpha_T}}}{A_N}, \tag{3.5}$$

where $\phi_1 = (r^*)^{\frac{\alpha_N - \alpha_T}{1-\alpha_T}} > 0$. Given that $\alpha_T > \alpha_N$, the non-tradable goods price P_N rises when A_T increases faster than A_N does. This scenario certainly highlights the Balassa-Samuelson effect in a standard two-sector model.

Underlying the Balassa-Samuelson effect is the wage linkage across sectors. The technological improvement in the tradable goods sector increases the marginal product of labor for workers in the sector and boosts real wages. Wages are equalized across sectors as a result of labor mobility; therefore, wages in the non-tradable goods sector also increases and boosts the price for non-tradable goods. In the process, real appreciation is observed along with TFP growth. Notably, the rise in wages is the key channel to generate the Balassa-Samuelson effect in the benchmark model. This channel may be insignificant when we observe abundant supplies of labor from rural areas during China's transition period. To investigate the role of abundant labor supply, we introduce excess supply of labor into the benchmark model.

At this point, we consider an economy with "surplus labor" from rural areas, and assume an exogenous minimum wage level $w_{\min}$. Therefore, the equilibrium for this economy is characterized by Equations (3.3) and (3.4) as well as two additional constraints:

$$w \geq w_{\min}, \tag{3.6}$$

$$L_T + L_N \leq L, \tag{3.7}$$

where L is total labor supply in this economy. In such an environment, capital cannot be perfectly mobile across borders, and the transmission of technological improvement across sectors relies on changes in the return to capital, which is determined endogenously.[7] In equilibrium, we can solve for return to capital as follows:

$$r = (w_{\min})^{1-\frac{1}{\alpha_T}} (A_T)^{\frac{1}{\alpha_T}}, \tag{3.8}$$

which implies that return to capital rises with the technological improvement in the tradable goods sector.

Hence, the price of the non-tradable goods is simply given as follows:

$$P_N = \phi_2 \frac{(A_T)^{\frac{\alpha_N}{\alpha_T}}}{A_N}. \tag{3.9}$$

where $\phi_2 = (w_{\min})^{1-\frac{\alpha_N}{\alpha_T}} > 0$. On the basis of Equation 3.9, we establish the following proposition.

Proposition 1 *When labor is abundant, the Balassa-Samuelson effect is weakened. That is, to induce real exchange rate appreciation, the growth rate of technology in the tradable goods and non-tradable goods sectors should satisfy the following condition* $\frac{g(A_T)}{g(A_N)} > \frac{\alpha_T}{\alpha_N} > 1$.

The proof is trivial. Consider a similar scenario wherein the tradable goods sector displays technological improvement; the price of non-tradable goods clearly increases, and real appreciation follows thereafter. The intuition is straightforward: although the wage of labor is depressed to the minimum level, technological improvement drives up the demand for capital, which in turn boosts the real interest rate and increases the price of non-tradable goods. P_N would drop if all sectors grow at the same rate. This result differs from that of the benchmark model, where the real exchange rate appreciates when $A_T > A_N$. This outcome implies that if the technologies in both sectors improve, the price of non-tradable goods does not rise unless the tradable goods sector grows much faster than the non-tradable goods sector does. Therefore, introducing "Surplus Labor" into the benchmark model exerts a new effect on real exchange rates; nevertheless, a weak version of the Balassa-Samuelson effect remains.

[7] If the goods trade is frictionless, wage and return to capital cannot be exogenously given in current modelling setup.

3.2 Three-Sector Model with "Surplus Labor"

To break the channel of the Balassa-Samuelson effect down further, we incorporate the H-O structure into the model. At this point, we consider an economy with three sectors: two tradable goods sectors and one non-tradable goods sector. The corresponding production functions are described as follows:

$$Y_{T_1} = A_{T_1}(\frac{N_{T_1}}{\beta_{T_1}})^{\beta_{T_1}}(\frac{L_{T_1}}{\alpha_{T_1}})^{\alpha_{T_1}}(\frac{K_{T_1}}{1-\alpha_{T_1}-\beta_{T_1}})^{1-\alpha_{T_1}-\beta_{T_1}}; \tag{3.10}$$

$$Y_{T_2} = A_{T_2}(\frac{N_{T_2}}{\beta_{T_2}})^{\beta_{T_2}}(\frac{L_{T_2}}{\alpha_{T_2}})^{\alpha_{T_2}}(\frac{K_{T_2}}{1-\alpha_{T_2}-\beta_{T_2}})^{1-\alpha_{T_2}-\beta_{T_2}}; \tag{3.11}$$

$$Y_N = A_N(\frac{L_N}{\alpha_N})^{\alpha_N}(\frac{K_N}{1-\alpha_N})^{1-\alpha_N}; \tag{3.12}$$

where N_i denotes skilled labor, L_i represents unskilled labor, and K_i corresponds to capital. $i = T_1, T_2, N$, which denote the two tradable goods sectors and the non-tradable goods sector, respectively.

Let r, w, and s represent the real return to capital, unskilled wage, and skilled wage, respectively. We normalize the price of goods to 1 and use P_{T_2} to indicate the price of the other tradable goods; P_N reflects the non-tradable goods. Note that P_{T_2} is exogenously given while P_N is endogenously determined. Thus, the aggregate price is simply given by $P = (P_{T_1})^{\theta_1}(P_{T_2})^{\theta_2}(P_N)^{1-\theta_1-\theta_2}$, where θ_1 and θ_2 are the shares of two tradable goods in the final goods. We maintain the assumption that both capital and labor are mobile across sectors. Therefore, the following conditions must be satisfied in an equilibrium when all sectors are operated:

$$1 = \frac{(s)^{\beta_{T_1}}\left(w^L\right)^{\alpha_{T_1}}(r)^{1-\alpha_{T_1}-\beta_{T_1}}}{A_{T_1}}, \tag{3.13}$$

$$P_{T_2} = \frac{(s)^{\beta_{T_2}}\left(w^L\right)^{\alpha_{T_2}}(r)^{1-\alpha_{T_2}-\beta_{T_2}}}{A_{T_2}}, \tag{3.14}$$

$$P_N = \frac{(w^L)^{\alpha_N}(r)^{1-\alpha_N}}{A_N}. \tag{3.15}$$

We still focus on an economy with excess labor supply. In this case, the unskilled-labor supply constraint is not binding; therefore, $w = w_{\min}$ in equilibrium. From Equations (3.13) and (3.14), we can solve for the return to capital:

$$r = \left(\phi_3 \frac{A_{T_2}^{\frac{1}{\beta_{T_2}}}}{A_{T_1}^{\frac{1}{\beta_{T_1}}}}\right)^{\frac{1}{\left(1-\alpha_{T_2}\right)/\beta_{T_2}-\left(1-\alpha_{T_1}\right)/\beta_{T_1}}}, \tag{3.16}$$

where $\phi_3 = P_{T_2}^{\frac{1}{\beta_{T_2}}} (w_{\min})^{\frac{\alpha_{T_1}}{\beta_{T_1}} - \frac{\alpha_{T_2}}{\beta_{T_2}}} > 0$. Without loss of generality, we assume that $\frac{1-\alpha_{T_2}}{\beta_{T_2}} - \frac{1-\alpha_{T_1}}{\beta_{T_1}} > 0$; that is, sector 1 is more skilled-labor intensity than sector 2. Based on Equation (3.16), we establish the following proposition.

Proposition 2 *When unskilled labor is abundant, the technological improvement in the (less) skilled labor-intensive tradable goods sector will lead to the (rise) decline of return to capital and then the (appreciation) depreciation of the real exchange rate.*

The proof is straightforward. As shown in Equation (3.15), the price of non-tradable goods is a function of interest rate and the wage of unskilled labor. A drop in interest rate may reduce P_N and induce real depreciation; thus, technological improvement that is biased toward sector 1 generates real depreciation. Moreover, if sector 1 is growing faster than sector 2 is, r may decline and then induce real exchange rate depreciation even if the technologies in both sectors are improving. Hence, the technology improvement in tradable goods sector may not necessarily generate real exchange rate appreciation. This finding suggests that uneven technology progress within the tradable goods sector and the abundant labor supply may reverse the Balassa-Samuelson effect.

4 A Three-sector Dynamic General Equilibrium Model

The setup discussed above is simple and involves only the supply side of the economy. This setup can be used to analyze the long-run trend of real exchange rates. However, such a framework, as interesting as it is, cannot be used to examine the current account dynamics and other issues given that the demand side is neglected. As described in this section, we extend previous static models to a dynamic setting and develop a theory of economic transition that is consistent with the empirical facts documented in Section 2. We consider a small open economy that takes the prices of tradable goods as given.

We assume that the home country has an excess supply of unskilled-labor in addition to two tradable sectors and a non-tradable sector. Three factors are available for production: skilled labor, unskilled labor, and capital. The tradable goods sectors use all three factors, whereas non-tradable goods sector utilizes only unskilled labor and capital.

4.1 Technology

The production functions in the three sectors are expressed as follows:

$$Y_j = A_j(\frac{N_j}{\beta_j})^{\beta_j}(\frac{L_j}{\alpha_j})^{\alpha_j}(\frac{K_j}{1-\alpha_j-\beta_j})^{1-\alpha_j-\beta_j}; j = 1,2 \tag{4.1}$$

$$Y_3 = A_3(\frac{L_3}{\alpha_3})^{\alpha_3}(\frac{K_3}{1-\alpha_3})^{1-\alpha_3}; \tag{4.2}$$

where N is skilled labor and L is unskilled labor. Sectors 1 and 2 are tradable goods sectors while sector 3 is the non-tradable goods sector. Capital and labor are presumably mobile across sectors.[8] In equilibrium, we have the following conditions:

$$wL_j = \alpha_j p_j y_j, \quad j = 1,2 \tag{4.3a}$$

$$sN_j = \beta_j p_j y_j \ , \quad j = 1,2 \tag{4.3b}$$

$$rK_j = (1-\alpha_j-\beta_j)p_j y_j, \quad j = 1,2 \tag{4.3c}$$

$$wL_3 = \alpha_3 p_3 y, \tag{4.3d}$$

$$rK_3 = (1-\alpha_3)p_3 y_3, \tag{4.3e}$$

where $p_j = \frac{(w)^{\alpha_j}(s)^{\beta_j}(r)^{1-\alpha_j-\beta_j}}{A_j}$, $j = 1,2$ and $p_3 = \frac{(w)^{\alpha_3}(r)^{1-\alpha_3}}{A_3}$ are the sector prices for tradable goods and non-tradable goods, respectively. We also assume that the unskilled-labor supply constraint is not binding; therefore, $w = w_{\min}$.

We assume that there is a representative final goods producer, who aggregates the three sectoral goods into the final goods, that is, $D_t = G(D_{1t}, D_{2t}, D_{3t})$. For simplicity, we consider a Cobb-Douglas aggregation, $D_t = \frac{(D_{1t})^{\theta_1}(D_{2t})^{\theta_2}(D_{3t})^{(1-\theta_1-\theta_2)}}{(\theta_1)^{\theta_1}(\theta_2)^{\theta_2}(1-\theta_1-\theta_2)^{(1-\theta_1-\theta_2)}}$. Given the aggregation structure, the consumer price index is simply given by $P = (p_1)^{\theta_1}(p_2)^{\theta_2}(p_3)^{(1-\theta_1-\theta_2)}$. In such a setting, we can simply define the real exchange rate as $\frac{1}{p_3^{(1-\theta_1-\theta_2)}}$.[9]

4.2 The Household's Problem

The economy is inhibited by a continuum of identical and infinitely lived households that can be aggregated into a representative household. The preference of the representative household over consumption can be summarized by $\sum_{t=0}^{\infty}\tilde{\beta}_t U(C_t)$, where C_t denotes the consumption of the final goods and $\tilde{\beta}_t$ is the discount factor between period 0 and t, as given by

$$\tilde{\beta}_{t+1} = \beta\left(\tilde{C}_t\right)\tilde{\beta}_t, \ t \geq 0,$$

[8] For convenient presentation, we drop the subscription of T and N for the traded goods and non-traded goods sectors.

[9] Note that, the prices of traded goods are constant in the model; therefore, the changes in the price of non-traded goods can reflect the changes in the real exchange rate.

where $\tilde{\beta}_0 = 1$ and $\beta_{\tilde{C}} < 0$. We assume that the endogenous discount factor does not depend on the consumption of an individual household, but rather on the average per capita consumption $\tilde{C}$, which an individual household takes as given. This preference specification was originally proposed by Uzawa (1968) and was introduced into the small open economy literature by Mendoza (1991).

The budget constraint and capital accumulation are expressed as follows:

$$P_t C_t + P_t I_t + P_t B_{t+1} + P_t \frac{\psi}{2} \left(B_{t+1} - \bar{B}\right)^2 = s_t N_t + w_t L_t + r_t K_t + (1 + r^*) P_t B_t, \tag{4.4}$$

$$(1 - \delta) K_t + I_t = K_{t+1}. \tag{4.5}$$

where N_t denotes skilled labor, L_t indicates unskilled labor, and r^* is the world interest rate, which is taken as given in our small open economy setup.

The first-order conditions with respect to C_t, K_{t+1}, and B_{t+1} yield the following:

$$U'(C_t) \left[1 + \psi \left(B_{t+1} - \bar{B}\right)\right] = (1 + r^*) \beta \left(\tilde{C}_t\right) U'(C_{t+1}), \tag{4.6}$$

$$U'(C_t) = \beta \left(\tilde{C}_t\right) U'(C_{t+1}) \left[1 - \delta + \frac{r_{t+1}}{P_{t+1}}\right]. \tag{4.7}$$

By using Equations (4.6) and (4.7), we immediately obtain

$$1 + \psi \left(B_{t+1} - \bar{B}\right) = \frac{1 + r^*}{1 - \delta + r_{t+1}/P_{t+1}}; \tag{4.8}$$

Therefore, households will choose to purchase additional foreign assets when the domestic interest rate decreases, thus resulting in capital inflow and current account surplus.

4.3 Characterization of Equilibrium

Now we are ready to characterize a competitive equilibrium. We first denote the aggregate demand of domestic residences for final goods as below

$$D_t = C_t + I_t + \frac{\psi}{2} \left(B_{t+1} - \bar{B}\right)^2. \tag{4.9}$$

Therefore, the domestic demands for tradable and non-tradable goods are given as follows, respectively,

$$D_{1t} = \theta_1 \frac{P_t D_t}{p_{1t}}, \tag{4.10}$$

$$D_{2t} = \theta_2 \frac{P_t D_t}{p_{2t}}, \tag{4.11}$$

$$D_{3t} = (1 - \theta_1 - \theta_2) \frac{P_t D_t}{p_{3t}}. \tag{4.12}$$

Let production in each sector j be Y^j. Then market clear condition for non-tradable goods requires:

$$Y_{3t} = D_{3t}. \tag{4.13}$$

The domestic factor markets also clear, implying that

$$N_1 + N_2 = N, \tag{4.14}$$

$$K_1 + K_2 + K_3 = K, \tag{4.15}$$

$$L_1 + L_2 + L_3 = L. \tag{4.16}$$

Given an excess supply of unskilled labor in the home country, wages are fixed at the minimum level $w_{\min}$.[10] The labor allocation constraint $L < L^s$ does not hold; L^s is the exogenous unskilled labor supply.

Finally, a competitive equilibrium consists of a set of prices, allocation rules, and trade shares, such that: (1) given the prices, all firm's inputs satisfy the FOCs and the outputs are given by the production functions. (2) Given the prices, the consumers' demand satisfies the first-order conditions derived from the household's problem, and the bonds holdings satisfy the asset pricing rule (4.8). (3) The prices ensure the market clearing conditions for labor, capital, non-tradable goods, and the household budget constraint.

5 Quantitative Analysis

5.1 Calibration

Our model is calibrated at annual frequency. The parameter values are summarized in Table 1. We assume the period utility function $u(c) = \frac{C^{1-\gamma}}{1-\gamma}$, where the inverse of the elasticity of intertemporal substitution $\gamma = 2$. The steady state discount factor $\beta = 0.96$, which implies a 4% annual world interest rate. Following Choi, Mark, and Sul (2008), the endogenous time discount factor takes the function form $\beta\left(\tilde{C}_t\right) = \beta\left(\frac{\tilde{C}_t}{\tilde{C}}\right)^{-\phi}$, where $\phi = 0.1$.

We assume that non-tradable goods constitute approximately 50% of the final goods and that the tradable goods have equal share in the final good; this implies that $\theta_1 = \theta_2 = 0.25$. We set the production parameters as follows: $\alpha_1 = 0.35, \beta_1 = 0.35$, $\alpha_2 = 0.1, \beta_2 = 0.1, \alpha_3 = 0.65$ such that the average capital shares in the tradable goods sector is 0.55 and 0.5, respectively; these shares are similar to those estimated from China's input-output table

[10] $w_{\min}$ can be an exogenously given function, depending on the gaps between the demand and supply of unskilled labor.

in 2002. The annual depreciation rate of capital δ is set to 0.1. Following Schmitt-Grohe and Uribe (2003), the coefficient for bond adjustment costs ψ_b is set to 0.0007. For simplicity, the value of the skilled-labor supply N is normalized to 1.

Table 1: Parameter Values in the Calibrations

β	discount factor in steady state	0.96
γ	inverse of the elasticity of intertemporal substitution	2
α_1	unskilled-labor share in sector 1	0.35
β_1	skilled-labor share in sector 1	0.35
α_2	unskilled-labor share in sector 2	0.1
β_2	skilled-labor share in sector 2	0.1
α_3	unskilled-labor share in sector 3	0.65
θ_1	share of goods 1 in the final goods	0.25
θ_2	share of goods 2 in the final goods	0.25
N	skilled-labor supply	1
ψ_b	coefficient for convex bond adjustment costs	0.0007
δ	capital depreciation rate	0.025
ϕ	parameter of endogenous discount factor	0.1
$\overline{B}$	initial bond level	0
A_1	productivity in sector 1	1
A_2	productivity in sector 2	1
$A3$	productivity in sector 3	1

It is assumed that sectoral productivity $A_1 = A_2 = A_3 = 1$ in the initial steady state. We further choose the prices of tradable goods prices to make $r = r^*$ so that $B = 0$ in the initial period. Given the prices, we pin down the initial unskilled-wage, which is assumed to be exogenous in the model. The numerical methods for solving steady state and transition dynamics are presented in Appendix A.

5.2 Results

As explained in this section, we evaluate the model quantitatively. Note that we are interested in the dynamics of the real exchange rate and current account in an economy featured with abundant unskilled labor supply as well as the experience of fast TFP growth in tradable good sector. Thus, we consider that our modeling economy starts from the initial steady state while $A_1 = 1$ and transits to the new steady state with $A_1 = 1.04$ while A_2 and A_3

remain unchanged.[11] Following Chen, Imrohoroglu, and Imrohoroglu (2006), we solve the transition dynamics with the shooting algorithm.

5.2.1 TFP Shocks and Wage Structure

Based on the evidence we described in Section 2, the exporting sector generically grows faster than importing sector does while China has maintained a high growth rate in the tradable goods sectors since 2001 (see Figure 6). Moreover, the supply of unskilled labor from rural areas has continually increased since the early 1990s, which drives the upward trend of skill premium. Significant controversies have arisen on whether or not China has reached the Lewis point, that is, whether or not an excess supply of unskilled labor is detected. Interestingly, Bai, Liu, and Wen (2015) recently reported that the skill premium began to decrease after 2008.

To capture the technological improvement in China after 2001, we normalize the TFP growth in both the import and non-tradable goods sectors and consider permanent TFP growth in the export sector. In particular, the TFP in this sector increases smoothly by 4%, whereas those of the other two sectors remain unchanged. Based on the aforementioned feature of the wage structure in China, we assume that the wage of unskilled labor remains constant in the early stage of our modeling economy. This rate then starts to increase at a slower rate than TFP growth (A_1). Eventually, both the TFP in the export sector and wage stop growing, and the economy arrives at the new steady state. The details of the TFP shocks and of the changes in wage structure are described in Figure 7.[12]

5.2.2 Factor Prices and Goods Prices

The effect of TFP shocks on factor prices are summarized in Figure 8. As we expected, the technological improvement in the export sector, which is the labor-intensive sector, leads to a fall in return to capital. Wage inequality continues to increase. At the early stage in which

[11] Since we normalize A_2 and A_3 in our simulation, our results of the variables can be interpreted as the departure from their long-run trend.

[12] Note that the wage structure of the unskilled labor is imposed exogenously in current version of our model. We can endogenize such a structure by incorporating a rural area from which the unskilled workers migrate to urban (see Bond et al., 2012 for similar settings). In the first stage of the economy, there are abundant unskilled labor in rural area and the migration cost is very low (closed to 0) . While in the later stage, most competent unskilled workers have moved to urban, the migration cost for the remaining unskilled workers is thus not negligible. The migration cost could be increasing with less and less unskilled labor residing in rural area. In such an environment, the wage structure will present the same pattern as we assumed in this paper.

the wage of unskilled labor is constant, the demand for skilled labor rises with TFP growth, which drives the upward trend of skill premium. During later periods, the wages for both unskilled and skilled worker start to increase while the unskilled labor constraint tightens. The skill premium may still increase, but its growth rate slows down slightly.

The technological improvement in the export sector also the prices of final goods. In our environment, the law of one price holds. Thus, the prices of tradable goods p_1 and p_2 are not affected by TFP shocks. The price of non-tradable goods p_3 responds to the shocks quite differently at the two stages. In the early stage wherein abundant unskilled labor supply and its wage w do not respond to technological improvement, the price of non-tradable goods drops with the decline of r. This result is straightforward since unskilled labor and capital alone are used for production in the non-tradable goods sector. In the later period, that is, the second stage in which the unskilled labor constraint starts to become binding, the wage of unskilled workers increases and boosts the price of the non-tradable goods. Moreover, the effect of rising wages on p_3 dominates that of decreasing return to capital, and overall, p_3 begins to rise in the second stage. The aggregate price P follows the same pattern as p_3: dropping at the first stage and then rising to the new steady state. The effects on the prices of goods are illustrated in Figure 8.

5.2.3 Real Exchange Rate, Trade, and Foreign Asset Holdings

Our paper focuses on the trend of real exchange rate. As the evidence presented above indicates, the Chinese real exchange rate depreciated first and then began to appreciate recently. Qualitatively, our model can replicate this interesting pattern.[13] The dynamics of real exchange rate are described in Figure 9.

Figure 9 also illustrates the dynamics of exports, imports, foreign asset holdings, and current accounts. With the technological improvement in the export sector, both the export and import sector expand and double in volume; this outcome is also qualitatively consistent with Chinese data suggesting that trade expanded rapidly after 2001. Meanwhile, net export is positive; therefore, the economy starts to accumulate additional foreign assets. The holdings of foreign bonds holdings rise significantly during this period from 0% to more than 3% of GDP. During entire periods with fast-growing TFP, the economy runs a current account surplus.

5.2.4 Factor Allocations, Aggregate Consumption, and Output

We compute the transition dynamics for factor allocations, aggregate consumption, and outputs. The results are summarized in Figure 10.

[13] Quantitatively, there still a large room to improve. Nonetheless, we will leave this aspect for subsequent research

With the accelerated TFP growth rate in the export sector, more resources unsurprisingly flow into this sector. The export sector begins to use increased amounts of capital, skilled labor, and unskilled labor, thereby driving up its output rapidly. Meanwhile, the expansion of the export section crowds out all factors for the other two sectors; as the result, output declines in these sectors. Interestingly, aggregate consumption, capital stock, and output drop with an increasing A_1.[14]

6 Cross-country Evidence

Conducting a full-fledged cross-country estimation for the determinant of the real exchange rate is beyond the scope of this work. In this section, we present some empirical evidence supporting our aforementioned hypothesis, that is, the accelerated TFP growth in the export sector over that in the import sector and the abundant unskilled labor supply depress real exchange rate appreciation.

6.1 Estimation Equations

At this point, we investigate the effect of the difference in the TFP growth of the export and import sectors as well as of the excess labor supply from rural to urban areas on the real exchange rate. We augment existing empirical models on the real exchange rate by including additional regressors such as the urban-rural migration rate and the gap between the growth rates of the export and import sectors. The latter is a proxy for the TFP difference between the export and import sectors. Conventional panel regressions with country and year fixed effects are presented as well.

Our estimation specification is as follows:

$$\log(RER)_{i,t}=\alpha+\beta_1\text{migration}_{i,t}+\beta_2\ \text{diff\_exim}_{it}+\beta_3\ \text{diff\_exim}_{it}*\text{migration}_{i,t}+X_{i,t}+\delta_i+\zeta_t+e_{it}$$

where $\log(RER)_{i,t}$ refers to the log of real exchange rate of country i in year t, $\text{migration}_{i,t}$ is the rural-urban migration rate of country i, diff_exim_{it} is determined by subtracting export growth rate from the import growth rate, and $\text{diff\_exim}_{it}*\text{migration}_{i,t}$ is an interaction term. $X_{i,t}$ denotes other determinants of the RER, which includes GDP per capita, government expenditure/GDP, terms of trade, net foreign asset/GDP, real interest rate, and tariff rate. The choice of control variables is guided by Rogoff (1996), the International Monetary Fund (2006), and Du, Wei, and Xie (2013). δ_i captures the country effect and ζ_t the year effect.

[14] Note that we normalize A_2 and A_3 in the model. Therefore, declines in consumpiton and output should not be intepreted as the reduction in level; rather, the results should be interpreted as relative sizes.

6.2 Data Description

We start with data for 248 economies worldwide over the period of 1996-2013. However, as some observations drop out due to missing values in different variables, we conduct the panel regression in this period for 82 economies, 70 countries, and 67 countries, as listed in Columns 1, 3-5, and 6, respectively. A list of countries is provided in Table 1 of Appendix. The definitions and descriptive statistics for key variables of interest are presented in Table 1; additional details, including data sources, are shown in Table 2 of Appendix.

Our independent variable is a country's real exchange rate (RER). Our measure of RER is the real effective exchange rate index of the International Monetary Fund, which is constructed by dividing the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) with a price deflator or index of costs. Since the nominal exchange rate enters the index in its inverse form, we inverse the term so that a rise in RER denotes real depreciation; this outcome is consistent with the conventional definition of the real exchange rate in our model. Note that the base year is 2010; as a result, only changes in log of RER, rather than in its absolute value, matter in cross-country comparison. In panel data, this issue is absorbed by the country fixed effects.

We utilize two key regressors. The first one is the urban-rural migration rate. We adopted the method of regional science to compute the country-level rural outmigration rate. The underlying assumption that total population growth does not stray too far from natural urban population growth appears to be rather strong at first glance; however, a close look at evidence suggests that the differences tend to be slight, at least for cross-country studies. The data for total population growth, urban population growth, and urban ratio are all available in the World Bank's World Development Indicator (WDI).

The second key regressor is an interaction term, which is the gap between the export and import growth rates multiplied by the migration rate. According to our three-sector model with "Surplus Labor," the technological improvement in the export sector alone does not induce real exchange rate depreciation. It is the coexistence of abundant unskilled labor and uneven technological improvement within tradable sectors is able to break down the Balassa-Samuelson effect. The data for export and import growth rates both originate from WDI.

We follow existing literature on the determinants of RER and include the following control variables: income per capita, government expenditure, net foreign assets, commodity terms of trade, real interest rate, and trade restriction. The detailed data sources of these variables are listed in Table 2 of the Appendix.

6.3 Panel Regression Results

Table 2 reports the panel regression results. Both country fixed effects and year fixed effects are included. We re-scale all the regressors by their standard deviations in the sample so that the magnitudes of the coefficients on variables become comparable with one another. Robust standard errors are clustered by country.

As per Column 1 of Table 2, migration rate alone is included as the key regressor aside from the control variables. The coefficient on migration is statistically significant and takes a positive sign. In accordance with our theory, an increase in migration rate by one standard deviation is associated with a 28% increase in the RER. In comparison, an improvement in per capita income by one standard deviation is associated with 49% real appreciation. A rise in government expenditure shares by one standard deviation is associated with an 7% appreciation in RER. These estimates suggest that the economic significance of urban-rural migration can be greater than half the Balassa-Samuelson effect and roughly four times stronger than the Froot-Rogoff effect.

According to Column 2 of Table 2, only export growth rate minus import growth rate is included aside from the control variables. The coefficient takes the expected sign, although this value is not significant. Based on Column 3, the coefficients of the two regressors do not change much when both migration rate and export growth rate minus import growth rate are included. Nonetheless, the potential explanatory power of the new variable is highlighted by a substantial increase in R-squared from approximately 0.20 to 0.35 and an enhancement in the significance level of the migration rate from 10% to 1%.

As per Column 4 of Table 2, an interaction term of migration rate and export growth rate minus import growth rate is included aside from the two regressors and in combination with other control variables. The coefficient on the interaction term is statistically significant and takes a positive sign, whereas the coefficient on migration rate is not significantly affected. This outcome suggests that the gap between the export and import sectors in technological progress can only influence the RER through surplus labor. That is, when migration rate is equal to zero, the TFP growth gap within sectors has no significant effect on real exchange rate. Specifically, if migration rate is at the level of one standard deviation, then an increase in the growth rate of the export sector relative to the import sector by one standard deviation is associated with a depreciation in RER of 3%-4% (as suggested by the true model presented in Column 5); this occurrence is comparable with the economic effect of the terms of trade. Furthermore, if migration rate is as high as two standard deviation levels, then the influence of the TFP growth rate gap is also doubled, and so forth.

6.4 Robustness Check

We acknowledge that there could be endogeneity problem resulting from simultaneity between RER and the growth of export and import. Furthermore, we recognize that another instance of endogeneity can arise from the possibility that current growth in export and import are not independent of past RERs. To control for such dynamic endogeneity and simultaneity, we employ the generalized method of moments (GMM) estimation procedure for dynamic panels as introduced by Arellano and Bond (1991) to our panel. Past values of RER and export growth minus import growth are used as internal instruments for current export growth minus import growth. This eliminates the need for external instruments (Wintoki, et al., 2012) .

First, we rewrite the regression model as a dynamic model that includes lagged RER as explanatory variables. Second, we empirically examine how many lags are required. Glen, Lee, and Singh (2001) and Gschwandtner (2005) suggest that two lags are sufficient to capture the persistence of dependent variables. To confirm if two lags can ensure dynamic completeness, we estimate a model with three lags and find that indeed, the first lag alone is statistically significant; other lags are insignificant.[15] Third, we apply the three higher lags of the endogenous variable, the Export_Import term as its own instruments. Finally, we estimate a one-step dynamic GMM estimator with robust stand error clustering on countries. The results are appended in Column 6 of Table 2. The Arellano-Bond test for the AR(1) first-order serial correlation tests yields a p-value of 0.0003, as expected for differenced errors. The AR(2) second-order serial correlation test generates a p-value of 0.1168 that fails to reject the null hypothesis of no second-order serial correlation. The Sargan test of over-identification produces a p-value of 0.2612; therefore we cannot reject the hypothesis that our instruments are valid.[16] Our baseline results hold qualitatively in this dynamic panel GMM regression setup, although the magnitude of coefficients varies slightly. We thus conclude that surplus labor and the higher growth of the export sector relative to the import sector typically cause RER depreciation.

7 Conclusion

This paper presents a simple theory to explain the dynamics of China's real exchange rate and other stylized facts during the fast-growing period since China joined the WTO. We argue that the faster TFP growth in the export sector over that in the import sector and the excess supply of unskilled labor may help explain the Chinese real exchange rate and other stylized facts, such as the significant current account surplus and the considerable rise of skilled wage premium. We first build two static models to explain why the real exchange rate may depreciate during this fast-growing period; subsequently, we develop a dynamic general model with an H-O structure and heterogenous (skilled vs unskilled) labor to explain the dynamics of both the real exchange rate and current account. Finally, we show that our

[15] In the table, the coefficients for lagged RER are suppressed because they are not of interest, but these coefficients are available upon request.

[16] We also conduct the system GMM introduced by Arellano and Bover (1995) and Blundell and Bond (1998) with the xtabond2 command in STATA as written by Roodman (2009). This approach yields Hansen J test, which is robust to heteroskedasticity. The results are qualitatively similar.

theory may be applied to other rapidly-growing developing countries through cross-country regression.

A Appendix (not for publication)

A.1 Steady State

In the steady state, w is exogenous since there is excess labor supply in home country. Moreover, $B_{t+1} = \bar{B}_h = 0$, $C_t = C_{t+1}$.[17]

A.1.1 Equilibrium Conditions

The following conditions must hold in a stationary equilibrium.

- Asset pricing for bonds:
$$\frac{r}{P} = r^* + \delta; \tag{A.1}$$
- Euler equation,
$$1 = \beta\left(\tilde{C}_{ht}\right)\left(1 - \delta + \frac{r_h}{P_h}\right) = \beta\left(\tilde{C}_{ht}\right)(1 + r^*)\,; \tag{A.2}$$
- 8 equations of efficient production, (4.3a);
- 3 unit cost equations and 1 Price index, (3.13)-(3.15);
- 3 Factor allocation across sectors:
$$N_1 + N_2 = N; \tag{A.3}$$
$$K_1 + K_2 + K_3 = K; \tag{A.4}$$
$$L_1 + L_2 + L_3 = L; \tag{A.5}$$
- Budget constraint,
$$P_t D_t = s_t N_t + w_t L_t + r_t K_t + r^* P_t B_t, \tag{A.6}$$

[17] Let's assume that there is no perpetual TFP growth in S.S. (it can be easily extended)

A.1.2 Computing the initial S.S.

Here is the steps that we solve for the steady state for our modeling economy. Note that in our SOE, $r^* = 1/\beta - 1$ taken exogenously.

1. $r^* = 1/\beta - 1$. Immediately, we obtain r/P
2. Given $w, p_1 = 1$, according to 4 equations of prices, we obtain $\{s, p_2, p_3, P\}$ as functions of r.
$$p_j = \frac{(w)^{\alpha_j} (s)^{\beta_j} (r)^{1-\alpha_j-\beta_j}}{A_j},\ p_3 = \frac{(w)^{\alpha_3} (r)^{1-\alpha_3}}{A_3};$$
$$\Longrightarrow s = \left[\frac{A_1 p_1}{(w)^{\alpha_1} (r)^{1-\alpha_1-\beta_1}}\right]^{\frac{1}{\beta_1}};$$
3. Use r/P, we can pin down r
4. Then pick N_1, we can solve for $\{N_2, Y_1, Y_2, K_1, K_2, L_1, L_2\}$
5. Given capital stock K, we can solve for $\{K_3, L_3\}$
6. Then N_1 can be pinned down by:
$$\frac{wL_3}{\alpha_3} = (1 - \theta_1 - \theta_2)(s_t N_t + w_t L_t + r_t K_t + r^* P_t B_t)$$
And thus, we can solve for the total labor supply when the constraint does not bind.

A.1.3 Computing the final S.S.

Note that $w = 0.4597$, $p_1 = 1$ and $p_2 = 0.5270$, which are given by the initial steady state.

1. given $\{w, p_1, p_2\}$, we can solve $\{r, s, p_3\}$ using unit cost functions
2. compute P by price index
3. since $r^* = 1/\beta - 1$. Immediately, we obtain B by $1 + \psi\left(B - \bar{B}\right) = \frac{1+r^*}{1-\delta+r/P}$
4. compute C by (A.2)
   - $\left(\frac{\tilde{C}_t}{C}\right)^{\phi} = \beta\left(1 - \delta + \frac{r_h}{P_h}\right)$
5. $P_t D_t$ is a function of K_t

- $PD = PC + P_t\delta K + P_t\frac{\psi}{2}\left(B_{t+1} - \bar{B}\right)^2$

6. thus, L_3 is a function of K

$$\frac{wL_3}{\alpha_3} = p_{3t}Y_{3t} = p_{3t}D_{3t} = (1 - \theta_1 - \theta_2)(P_tD_t)$$

7. once we get L_3, we have $y_3\&K_3$ as a function of K

$$\begin{aligned} wL_3 &= \alpha_3 p_3 y_3, \\ rK_3 &= (1-\alpha_3)p_3y_3, \end{aligned}$$

8. from resource reallocation, $\{K_1, K_2, N_1, N_2, L_1, L_2, L\}$ are functions of K

$$\begin{aligned} wL_j &= \alpha_j p_j y_j, \quad j = 1,2 \\ sN_j &= \beta_j p_j y_j \ , \quad j = 1,2 \\ rK_j &= (1-\alpha_j-\beta_j)p_jy_j, \quad j = 1,2 \end{aligned}$$

$$\Longrightarrow k_j^N = \frac{K_j}{N_j} = \frac{(1-\alpha_j-\beta_j)}{\beta_j}\frac{s}{r};$$

- $k_1^N N_1 + k_2^N N_2 = K - K_3 \Longrightarrow N_1 = \frac{K-K_3-k_2^N N}{k_1^N - k_2^N} \Longrightarrow N_2, K_1, K_2$
- $sN_j = \beta_j p_j y_j \Longrightarrow y_1\&y_2$
- $wL_j = \alpha_j p_j y_j \Longrightarrow L_1\&L_2$

9. Finally, the budget constraint (A.6) will pin down K

$$P_tD_t = s_tN_t + w_tL_t + r_tK_t + r^*P_tB_t$$

Therefore, we solved the case where there is unskilled labor surplus.

A.2 Transition Dynamics

We are interested in the transition dynamics of the real exchange rate for an economy with abundant unskilled labor supply that experiences fast TFP growth in tradable good sector. Therefore, it is necessary to go beyond the steady state analysis and compute the transition path for the economy facing a permanent TFP shock.

Consider the economy starts from initial steady state. Now suppose A_1 increases from 1.0 to 1.04, while A_2 and A_3 stay unchanged. Following Chen, Imrohoroglu and Imrohoroglu (2006), we use shooting algorithm to solve the dynamics. Here is the details:

1. given TFP series, wage and exogenous prices of tradable goods, we can solve for $\{r_t, s_t, p_{3,t}, P_t, B_{t+1}\}$

    (a) solve $\{r_t, s_t, p_{3,t}\}$ using unit cost functions

    (b) compute P by price index

    (c) B_{t+1} is given by $1+\psi\left(B_{t+1}-\bar{B}\right)=\frac{1+r^*}{1-\delta+r_{t+1}/P_{t+1}}$;

2. Given current period capital stock, K_t, solve the real allocations.

    (a) compute aggregate demand

$$P_t D_t = s_t N_t + w_t L_t + r_t K_t + (1+r^*) P_t B_t - P_t B_{t+1}$$

    (b) Compute L_{3t}, Y_{3t} :

$$\frac{wL_3}{\alpha_3} = p_{3t} Y_{3t} = p_{3t} D_{3t} = (1-\theta_1-\theta_2)(P_t D_t)$$

    (c) once we get L_{3t}, we have $y_{3t} \& K_{3t}$ as a function of K

$$\begin{aligned} wL_3 &= \alpha_3 p_3 y_3, \\ rK_3 &= (1-\alpha_3) p_3 y_3, \end{aligned}$$

    (d) from resource reallocation, we obtain $\{K_1, K_2, N_1, N_2, L_1, L_2, L\}$

$$k_j^N = \frac{K_j}{N_j} = \frac{(1-\alpha_j-\beta_j)}{\beta_j}\frac{s}{r};$$

$$N_1 = \frac{K - K_3 - k_2^N N}{k_1^N - k_2^N}.$$

    and then solve for $N_2, K_1, K_2, L_1, L_2, y_1, y_2$.

3. Guess K_{t+1},

    (a) get investment and consumption as follows:

$$I_t = K_{t+1} - (1-\delta) K_t;$$

$$C_t = D_t - I_t - \frac{\psi}{2}\left(B_{t+1}-\bar{B}\right)^2.$$

(b) can compute next period consumption by:

$$(C_{t+1})^{\rho+\phi} = \beta (C_t)^{\rho} (\bar{C})^{\phi} \left[1 - \delta + \frac{r_{t+1}}{P_{t+1}}\right];$$

(c) compute real allocations in period $t+1$, $D_{t+1}, L_{t+1}, Y_{t+1}, ...$ following step 2

(d) compute I_{t+1} by

$$I_{t+1} = D_{t+1} - C_{t+1} - \frac{\psi}{2} \left(B_{t+2} - \bar{B}\right)^2$$

(e) thus, we obtain K_{t+2} by

$$K_{t+2} = I_{t+1} + (1-\delta) K_{t+1}.$$

and iterate.

4. If diverge, adjust initial guess and go to step 3.

The above algorithm can find a stable transition path to the new steady state for the emerging economy.

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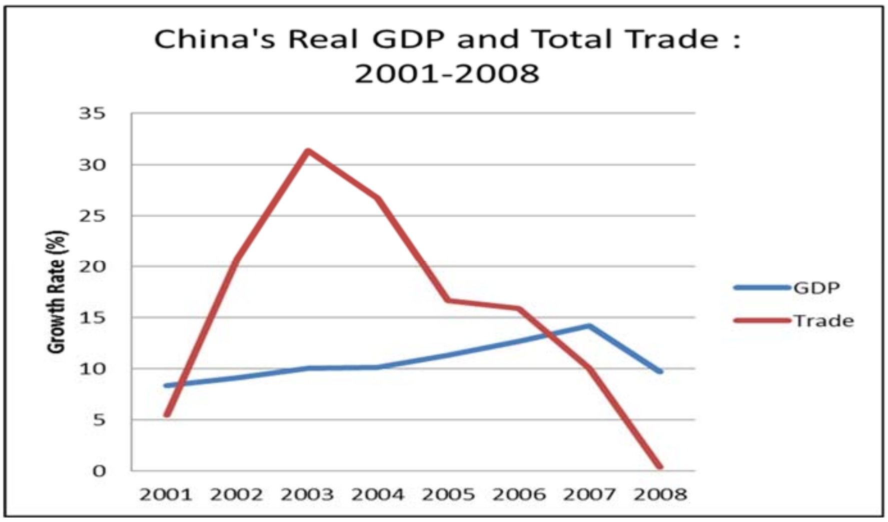
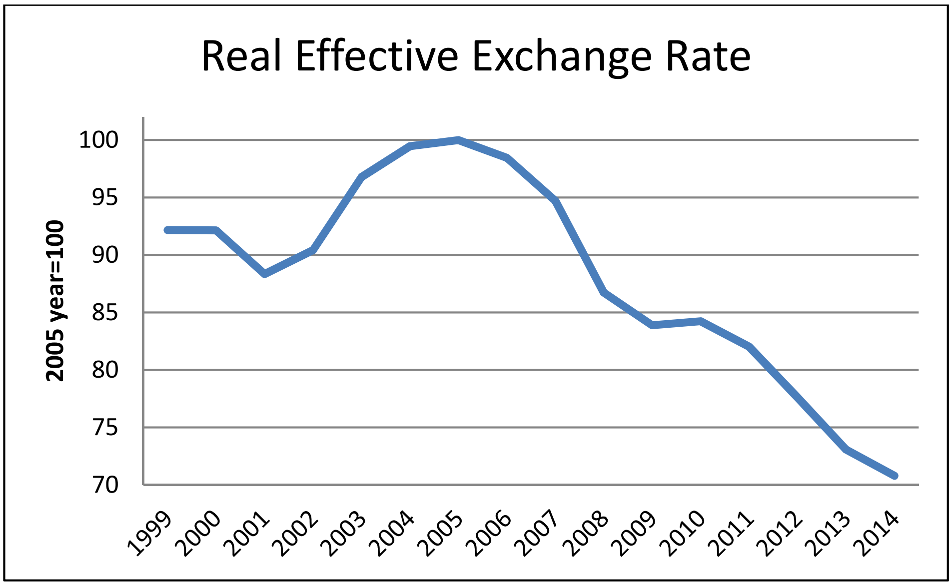
Figure 1:



Source: National Bureau of Statistics of China

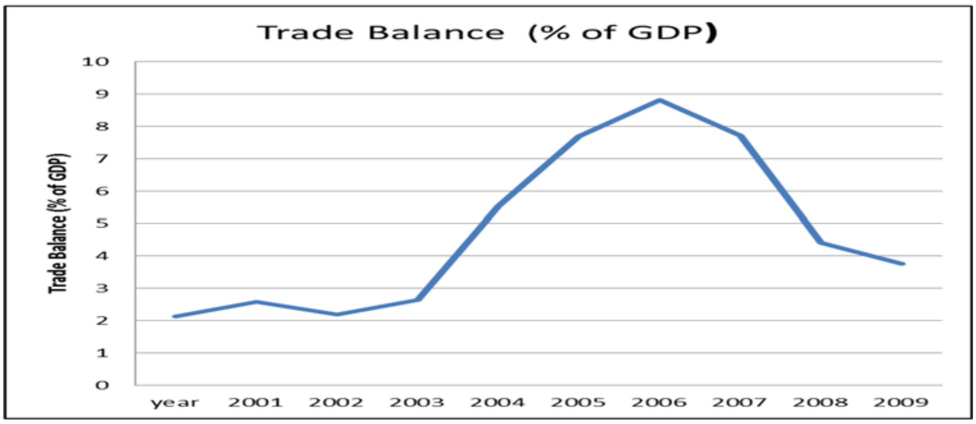
Figure 2:



Source: International Monetary Fund, International Financial Statistics

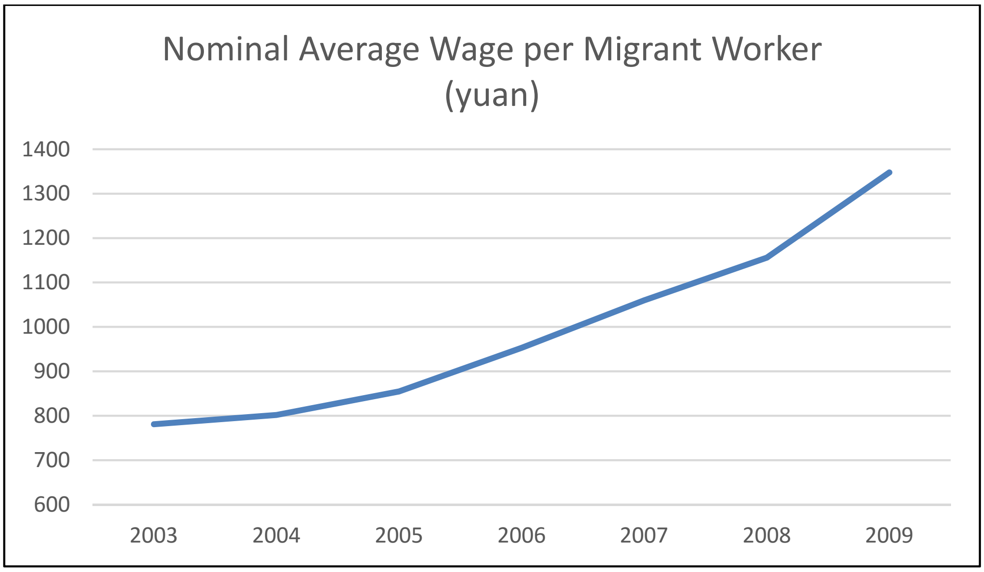
Real effective exchange rate index (2010 = 100)

Figure 3:



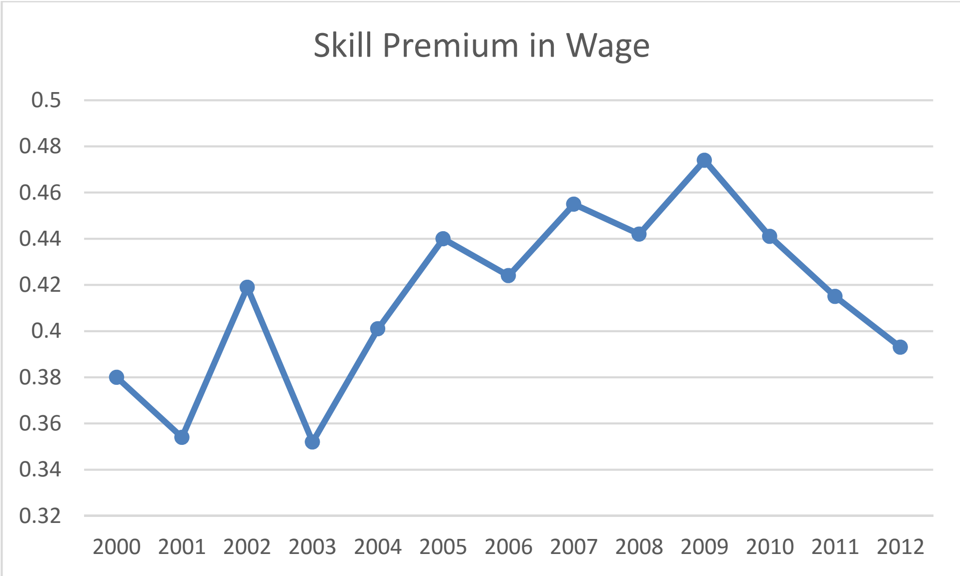
Source: International Monetary Fund, Balance of Payments Statistics Yearbook and data files

Figure4:



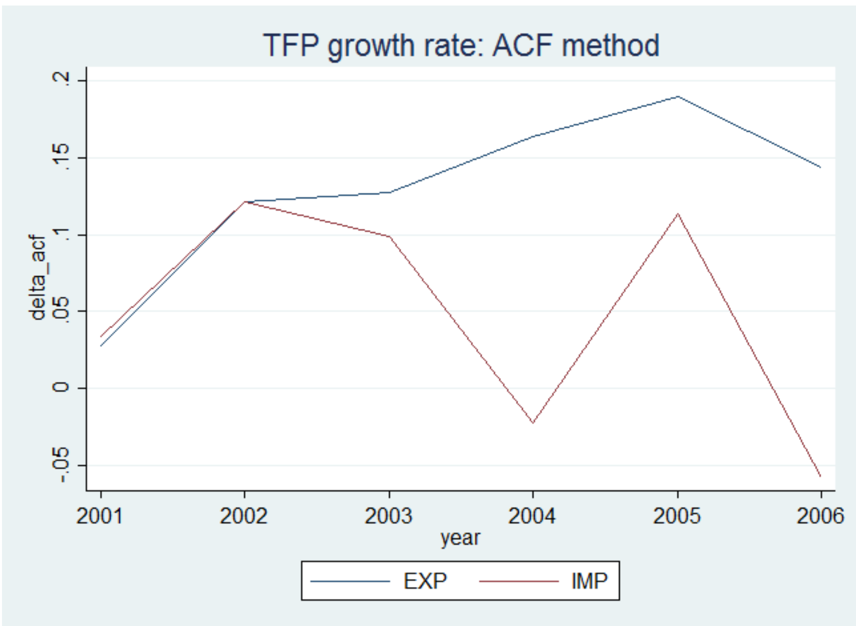
Source: Zhao and Wu (2008) for 2003-6; Ministry of Agriculture (2010) for 2007-9

Figure 5:



Source: UHS data, computation results from Bai, Liu and Yao (2015)

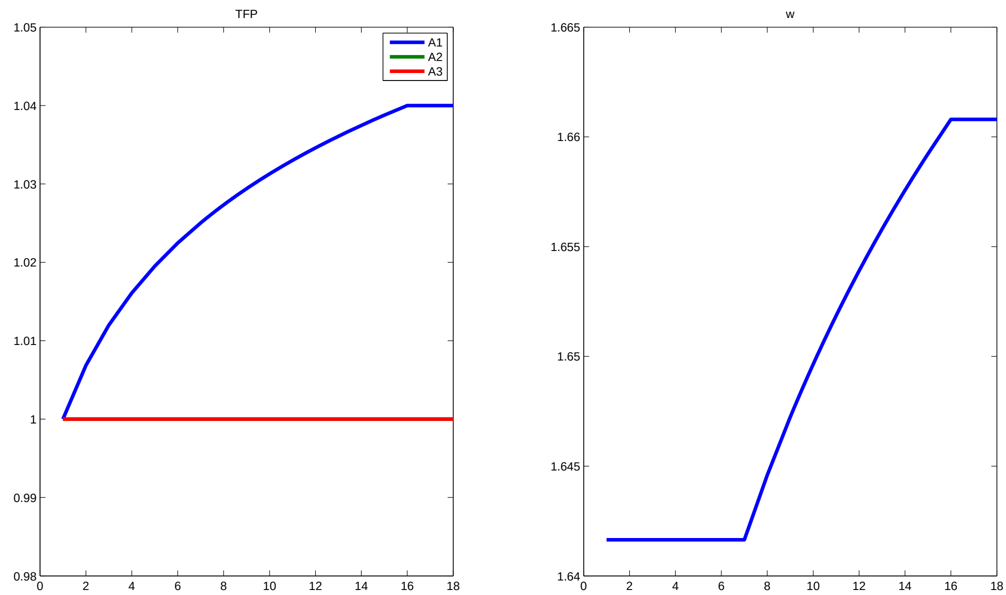
Figure 6:



Source: Author's Computation using the Chinese manufacturing

data and Chinese custom data

Figure 7:



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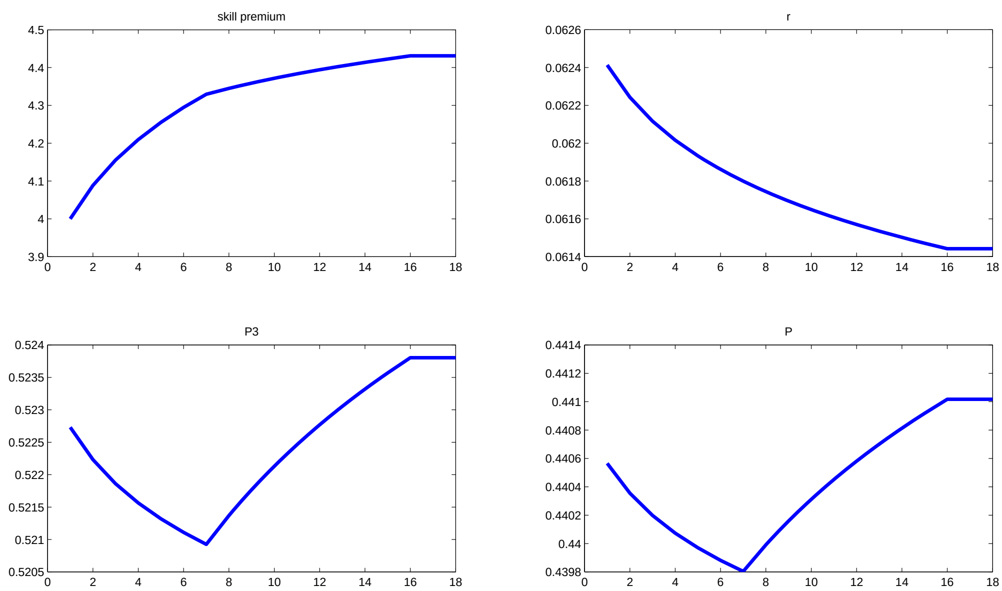

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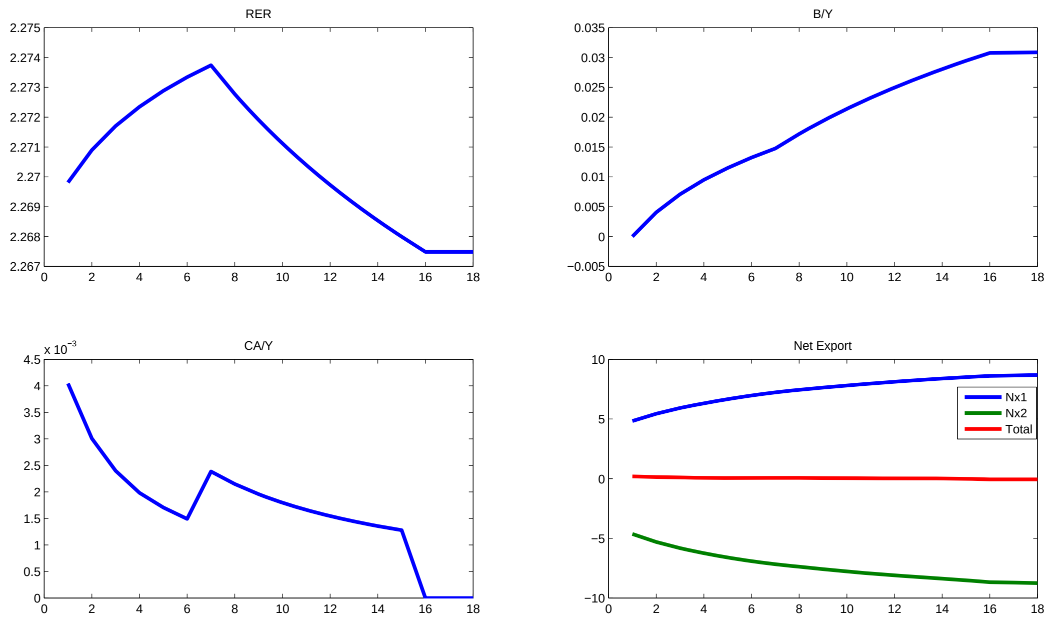

Figure 10: Factor Allocations, Aggregate Consumption and Output

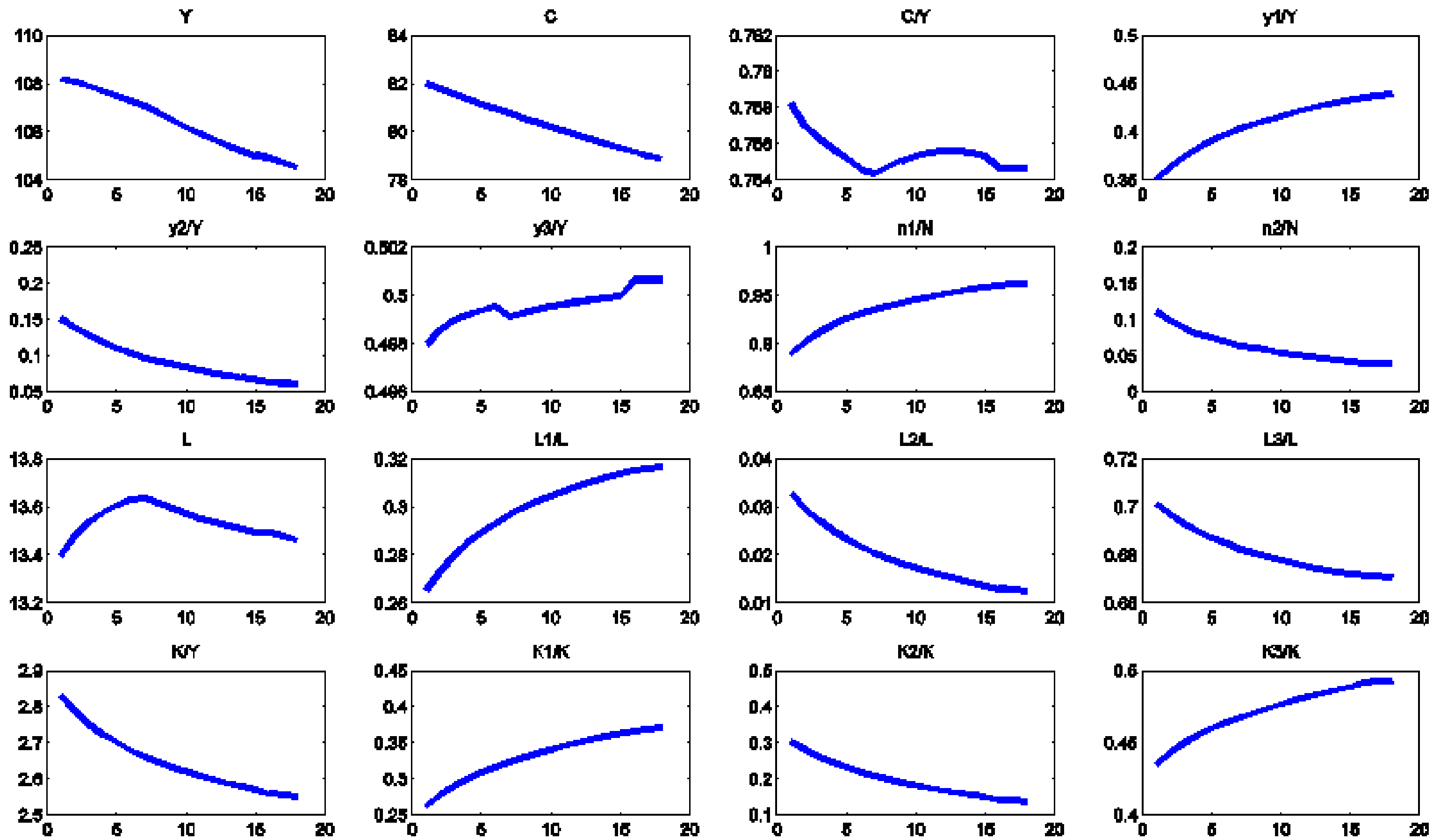

Table 1: Definition and Summary Statistics of Key Variables for Cross Countries (1996-2013)

Variable Definitions	Variable Names	Obs	Mean	Std. Dev.	Min	Max
RER = Real Exchange Rate	***Log (100/REER*100)***	1689	4.56	0.24	2.28	5.60
Migration Rate = $(\mu_t-\rho_t)u_t/(1-u_t)$	***Migration Rate***	4278	0.98	5.51	-5.08	350.72
Export_Import_Developing = Export growth rate – import growth rate	***Diff_exim***	2835	-0.26	7.50	-20.45	21.57
Log GDP per capita in 2011 PPP dollars	***Log GDP/capita***	3942	8.98	1.22	5.02	11.84
GOV/GDP = (government expenditure/GDP)	***GOV/GDP***	3676	16.19	7.96	2.05	156.53
Terms of Trade (ToT)= Net barter terms of trade index (2000 = 100)	***Terms of Trade***	3105	108.17	32.19	21.22	262.09
Net Foreign Asset/GDP	***NFA/GDP***	3126	0.25	0.82	-1.98	14.06
Real Interest Rate, in %	***Real Interest Rate***	2565	8.14	20.07	-96.87	572.94
Tariff Rate = Trade weighted applied tariff rate, in percentage points	***Tariff Rate***	2108	7.22	8.87	0.00	254.58

Data Sources: For detailed information on data sources and definition of terms, please refer to Appendix Table 2

Table 2: Panel Regressions

Dependent Variable	**Log Real Exchange Rate(Index 2010=100)**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Migration Rate	0.283*		0.274***	0.267***	0.265***	0.136***
	(0.148)		(0.0898)	(0.0915)	(0.0923)	(0.0344)
Diff_exim		0.00612	0.00613	0.00225		1.34e-05
		(0.00534)	(0.00537)	(0.00581)		(0.00587)
Diff_exim *Migration Rate				0.0322*	0.0384**	0.0534***
				(0.0184)	(0.0190)	(0.0175)
lgdp_pcsd	-0.493***	-0.507***	-0.546***	-0.544***	-0.543***	-0.330**
	(0.0756)	(0.105)	(0.107)	(0.105)	(0.105)	(0.136)
gov_gdpsd	-0.0698**	-0.102*	-0.105*	-0.103*	-0.102*	0.0258
	(0.0335)	(0.0560)	(0.0566)	(0.0571)	(0.0574)	(0.0258)
totsd	-0.0229	-0.0417**	-0.0340**	-0.0348**	-0.0350**	-0.000561
	(0.0259)	(0.0161)	(0.0169)	(0.0171)	(0.0172)	(0.0293)
nfa_gdpsd	0.0983**	0.147**	0.144***	0.145***	0.144***	0.0469**
	(0.0413)	(0.0556)	(0.0508)	(0.0516)	(0.0514)	(0.0230)
rirsd	-0.00195	-0.0454	-0.0439	-0.0447	-0.0444	-0.0265**
	(0.0178)	(0.0302)	(0.0287)	(0.0283)	(0.0283)	(0.0122)
tariffsd	-0.0554	-0.0312	-0.0306	-0.0322	-0.0323	0.0230
	(0.0348)	(0.0474)	(0.0469)	(0.0470)	(0.0470)	(0.0163)
Observations	710	599	585	585	585	448
R-squared	0.198	0.331	0.348	0.350	0.350	/
Number of id	82	71	70	70	70	67
Country FE	YES	YES	YES	YES	YES	/
Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix Table 1: List of countries used in the cross-country sample

82 countries included in Column 1 are: Algeria*, Antigua and Barbuda, Armenia*, Australia*, Bahamas*, The, Bahrain*, Belgium*, Belize*, Bolivia*, Bulgaria*, Burundi*, Cameroon*, Canada*, Central African Republic*, Chile*, China*, Colombia*, Congo, Dem. Rep. *, Costa Rica*, Croatia*, Cyprus*, Czech Republic*, Denmark*, Dominica, Dominican Republic*, Ecuador*, Equatorial Guinea*, Fiji, Finland*, France*, Gabon*, Gambia, The, Georgia*, Germany*, Greece*, Grenada, Guyana, Hungary*, Iceland*, Iran, Islamic Rep. *, Ireland*, Israel*, Italy*, Japan*, Lesotho*, Macedonia, FYR*, Malawi*, Malaysia*, Malta*, Mexico*, Moldova*, Morocco*, Netherlands*, New Zealand*, Nicaragua*, Nigeria*, Norway*, Pakistan*, Papua New Guinea*, Paraguay*, Philippines*, Poland*, Romania*, Russian Federation*, Sierra Leone, Slovak Republic*, Solomon Islands, South Africa*, Spain*, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sweden*, Switzerland*, Tonga, Trinidad and Tobago*, Uganda*, Ukraine*, United Kingdom*, United States*, Uruguay*, Venezuela, RB*

Notes: A subset of 70 countries, denoted by a “*”, are also included in Column 3 – 5.

Appendix Table 2: Detail of Data Resource and Definition

No.	Variable	Component	Source
1	Real Exchange Rate (2010=100)	Real Effective Exchange Rate Index (2010=100)	World Bank: http://data.worldbank.org/indicator/PX.REX.REER
2	Migration Rate	Rate of growth of total population (annual %)	World Bank: http://data.worldbank.org/indicator/SP.POP.GROW
		Rate of growth of urban population (annual %)	World Bank: http://data.worldbank.org/indicator/SP.URB.GROW
		Urban population (% of total)	World Bank: http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS
3	Diff_exim	Exports of goods and services (annual % growth)	World Bank: http://data.worldbank.org/indicator/NE.EXP.GNFS.KD.ZG
		Imports of goods and services (annual % growth)	World Bank: http://data.worldbank.org/indicator/NE.IMP.GNFS.KD.ZG
4	GDP per capita	GDP, PPP (constant 2011 international $)	World Bank: http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD
5	GOV/GDP	General government final consumption expenditure (% of GDP)	World Bank: http://data.worldbank.org/indicator/NE.CON.GOVT.ZS
		GDP (current LCU)	World Bank: http://data.worldbank.org/indicator/NY.GDP.MKTP.CN
6	Terms of Trade	Net barter terms of trade index (2000 = 100)	World Bank: http://data.worldbank.org/indicator/TT.PRI.MRCH.XD.WD
7	Net Foreign Assets/GDP	Net foreign assets (current LCU)	World Bank: http://data.worldbank.org/indicator/FM.AST.NFRG.CN
8	Real interest rate (%)	Lending interest rate adjusted for inflation, GDP deflator	World Bank: http://data.worldbank.org/indicator/FR.INR.RINR
9	Tariff Rate	Net barter terms of trade index (2000 = 100)	World Bank: http://data.worldbank.org/indicator/TT.PRI.MRCH.XD.WD