

# The Global Impact of Chinese Growth\*

Ippeii Fujiwara, Keisuke Otsu and Masashi Saito<sup>†</sup>  
Bank of Japan

December 10, 2007

## Abstract

Three decades have passed since China dramatically opened-up to the global market and began to catchup rapidly to leading economies. In this paper we discuss the effects of the Chinese opening-up and rapid growth on the welfare of both China and the rest of the world (ROW). We show that the Chinese opening-up per se is welfare improving for China but had little impact on the ROW given a balanced trade constraint. The opening-up of China is beneficial to the ROW if it led to significant productivity growth in China.

*Keywords:* Productivity, Terms of Trade, Growth, Open Economy

*JEL Classification:* E13, F41, O40

## 1 Introduction

Chinese output growth suddenly took-off in 1978. This corresponds to the sudden increase in the “openness”, i.e. the trade volume to GDP ratio. The

---

\*Conversations with Maury Obstfeld, Bennet McCallum, Toni Braun, Chang-Tai Hsieh, Mick Devereux, Gary Hansen and Lee Ohanian are deeply appreciated. The authors also thank Naoko Hara and Andrea Raffo for technical advice.

<sup>†</sup>Fujiwara: Corresponding author. Director and Senior Economist, Institute for Monetary and Economic Studies, Bank of Japan, 2-1-1 Nihonbashi-Hongokuchō Chūō-ku, Tokyo 103-8660. Email: ippei.fujiwara@boj.or.jp. Otsu: Economist, Institute for Monetary and Economic Studies, Bank of Japan. Saito: Economist, Research and Statistics Department, Bank of Japan.

rest of the world (ROW), which we define as the aggregate of G7 countries, grows constantly over the 1950-2005 period regardless of the dramatic opening-up and take-off of China. Shouldn't the ROW be affected by the entry of China? In this paper, we use a standard two-country neoclassical model to quantitatively assess the global effects of the shocks to China and show that the opening-up can be welfare improving for both China and the ROW if it led to significant productivity growth.

The key facts of the Chinese economy are threefold. First, soon after the "Reform and Opening-up" policy was enacted in 1978, the trade volume to GDP ratio increased roughly from 0.1 to 0.4. Second, the annual growth rate of GDP per capita was around 2.5% until 1978 whereas it jumped up to roughly 8% on average over the 1978-2004 period. Finally, trade was roughly in balance throughout the pre-1978 period. In this paper, we elicit shocks which replicate these facts in the Chinese economy and deduce their impacts on the ROW within a standard neoclassical two-country two-good model à la Backus, Kehoe and Kydland (BKK(1994)).

Two key shocks to the Chinese economy we assume are the reduction in home bias and the gradual productivity growth. Home bias determines the share of home goods among intermediate goods used to produce domestic final goods. We assume that the Chinese government can directly affect home bias through industrial policy. Thus, a sudden reduction in home bias represents the opening-up policy.

Several studies assess the importance of TFP in explaining the rapid growth in post 1978 China. For instance, Dekle and Vandenbroucke (2006) argue that the shift in labor from agriculture and public non-agriculture sectors to private non-agriculture sectors was a major contributor to the growth in TFP. On the other hand, Young (2003) claims that the growth rate of non-agricultural economy is "respectable but not outstanding". Islam, Dai and Sakamoto (2006) computes TFP growth with the dual approach introduced by Hsieh (2002) and found that the post-reform Chinese TFP growth was high but recently decelerated. Instead of focusing on the source of TFP growth in China, we take productivity growth as given and deduce its impact on both China and the ROW.

In addition to the two key shocks, we also assume Chinese import tariffs in our model. Prior to the reform in 1978, Beijing imposed several direct regulations on trade. The trade policy during this period was to merely finance the imports of targeted goods by exporting products redundant in the domestic market. For simplicity, we assume that the Chinese government

imposed tariffs on imports in order to maintain balanced trade. Since data of tariffs in the context of our model is not available, we simply impose a balanced trade constraint and back-out the tariffs needed to maintain this constraint. The justification of this constraint is perhaps less convincing for the post 1978 period as China gradually reduced tariff rates and removed non-tariff barriers following GATT and WTO protocols.

The fact that the ROW did not seem to react much to the large shocks in China is surprising given that China is the largest country in the world in terms of population and second largest in terms of total GDP. In specific, in a two-country one-good model such as Baxter and Crucini (1995), there should be high correlation between movements in consumption across countries. However, practically no consumption risk sharing between China and the ROW seems to have taken place. Thus, we consider a two-country two-good model in which the terms of trade provides a cushion for consumption risk sharing. Each country trades intermediate goods that are aggregated with a constant elasticity of substitution technology in order to satisfy aggregate demand. The aggregation technology is characterized by the elasticity of substitution between home goods and foreign goods as well as the degree of home bias.

Using the model with the balanced trade constraint, we compute home bias and productivity shocks which generate openness and output that match data. Then we simulate the model given these shocks. Our results show that the sudden reduction in Chinese home bias per se is welfare improving for China but had little impact on the ROW. On the other hand, the productivity growth in China is welfare improving for both economies. Thus, we conclude that the opening-up policy is welfare improving for both economies if it led to significant productivity growth.

The rest of the paper is organized as follows. In section 2, we document the data on China focusing on the opening of trade and the growth in GDP components. In section 3, we describe the model. In section 4, we present the quantitative results. Section 5 concludes the paper.

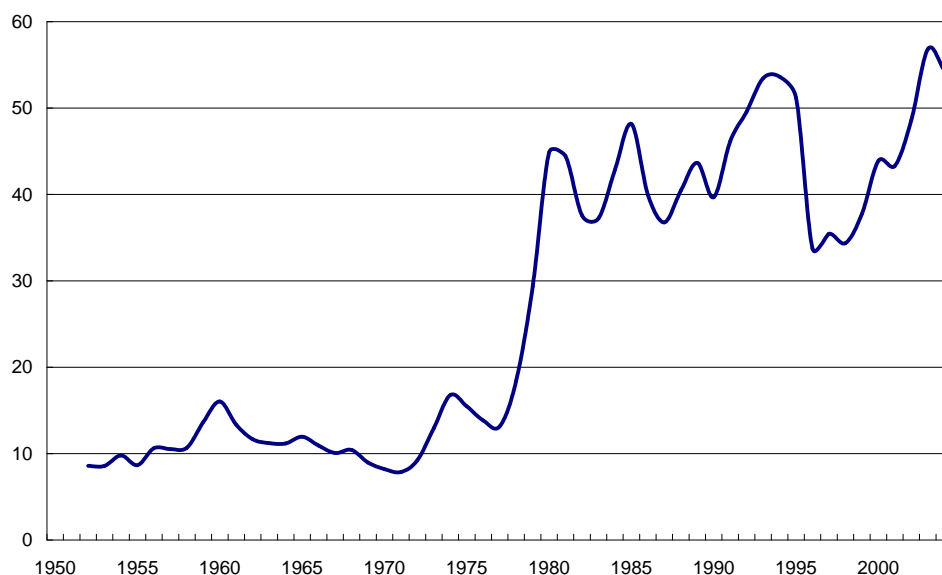
## 2 The Opening-up and Growth of China

In this section, we describe the key features of the Chinese economy over the 1950-2004 period. Most of the data are from Penn World Table 6.1 and are stated otherwise.

## 2.1 Openness

Figure 1 presents the “openness” of China defined as Trade Volume/GDP in real terms<sup>1</sup>. The sudden increase in trade in 1978 corresponds to the beginning of the “Reform and Opening-up (*Gaige Kaifang*) policy”. The entry of China to the World Trade Organization in 2001 surely increased the trade volume, however, historically speaking, the opening-up policy had a much greater impact on openness.

Figure 1. Chinese Openness



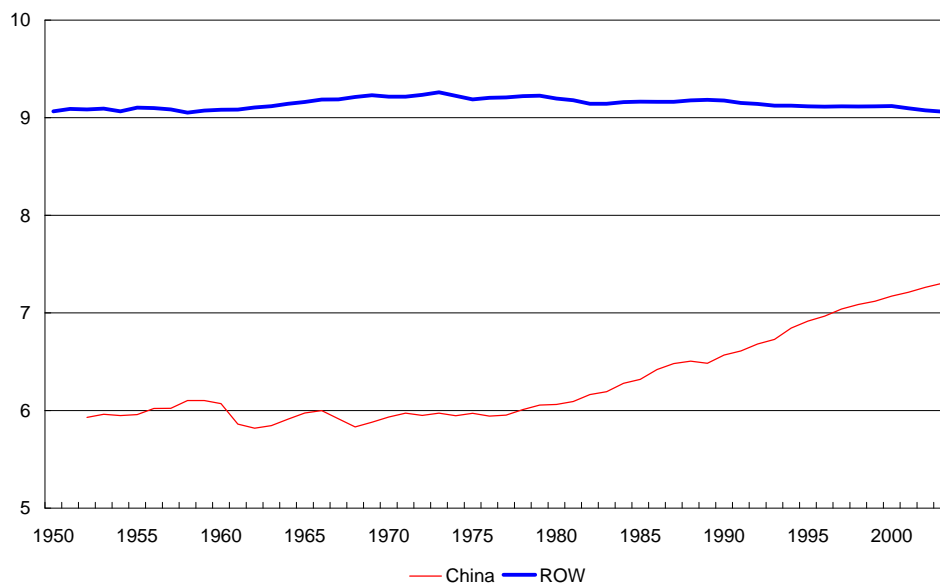
As described in Shirk (1994), the main aim of trade policy prior to 1978 was import-substitution. The government especially protected steel and machinery industries from foreign competition by controls on imports, investment, capital flows and exchange rates. Trade was limited to the central foreign trade ministry and its twelve trade corporations. They exported agricultural and primary goods in order to finance the controlled imports of mainly industrial equipment. In 1978, as a part of the reform, four cities were named special economy zones and invited foreign investment. These economic zones produce export goods in which they have competitive advantage, namely labor intensive goods.

<sup>1</sup>Note that this measure includes trade with non G7 countries as well.

## 2.2 Growth

Figure 2 presents GDP per economically active population (EAP)<sup>2</sup> in China and ROW. The series are in log terms and linearly detrended with the average annual growth rate of the ROW GDP per EAP 2.5%.

Figure 2. Output



This figure shows that China was growing roughly at the same rate as ROW prior to the opening-up. Once the economy opened up, the Chinese growth rate took-off. The average annual growth rate during the post reform period is nearly 8% while it was roughly 2.5% during the 1950-1978 period.

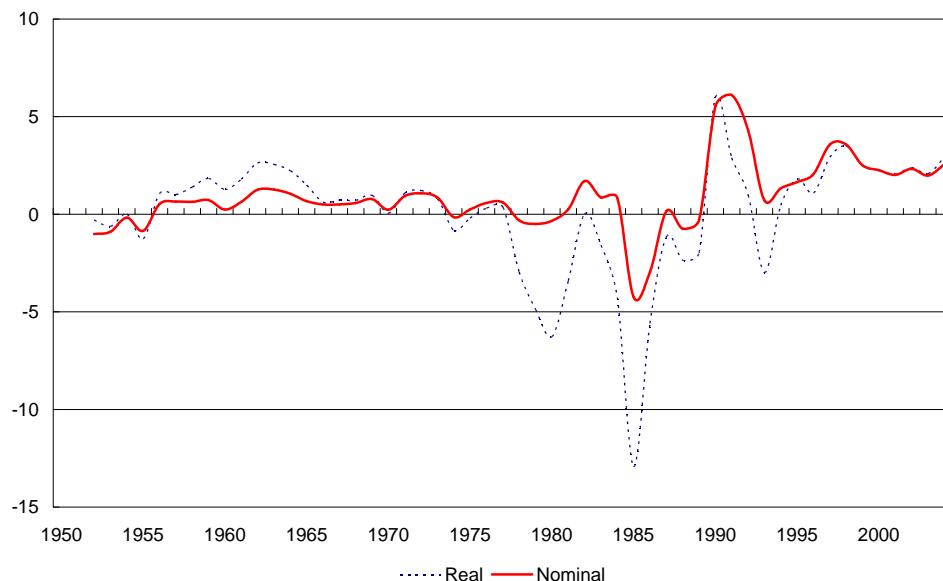
## 2.3 Trade Balance

Figure 3 presents the Chinese trade balance to GDP ratio. The trade balance is computed as the difference between output and domestic absorption. The trade balance is a tricky variable for two reasons. First, as for the openness, since we omit many countries, the trade balance of ROW is not exactly the mirror image of the trade balance of China. Since the trade balance of ROW

<sup>2</sup>This series correspond to GDP per worker in PWT 6.1 where PWT defines “worker” as economically active population.

is not a variable of our interest, we focus only on the Chinese trade balance. Second, since trade balance is computed as a residual, its real measure is affected by omissions and fluctuations in PPP adjusted relative prices. We also provide the nominal measure which is not affected by fluctuations in price deflators.

Figure 3. Chinese Trade Balance

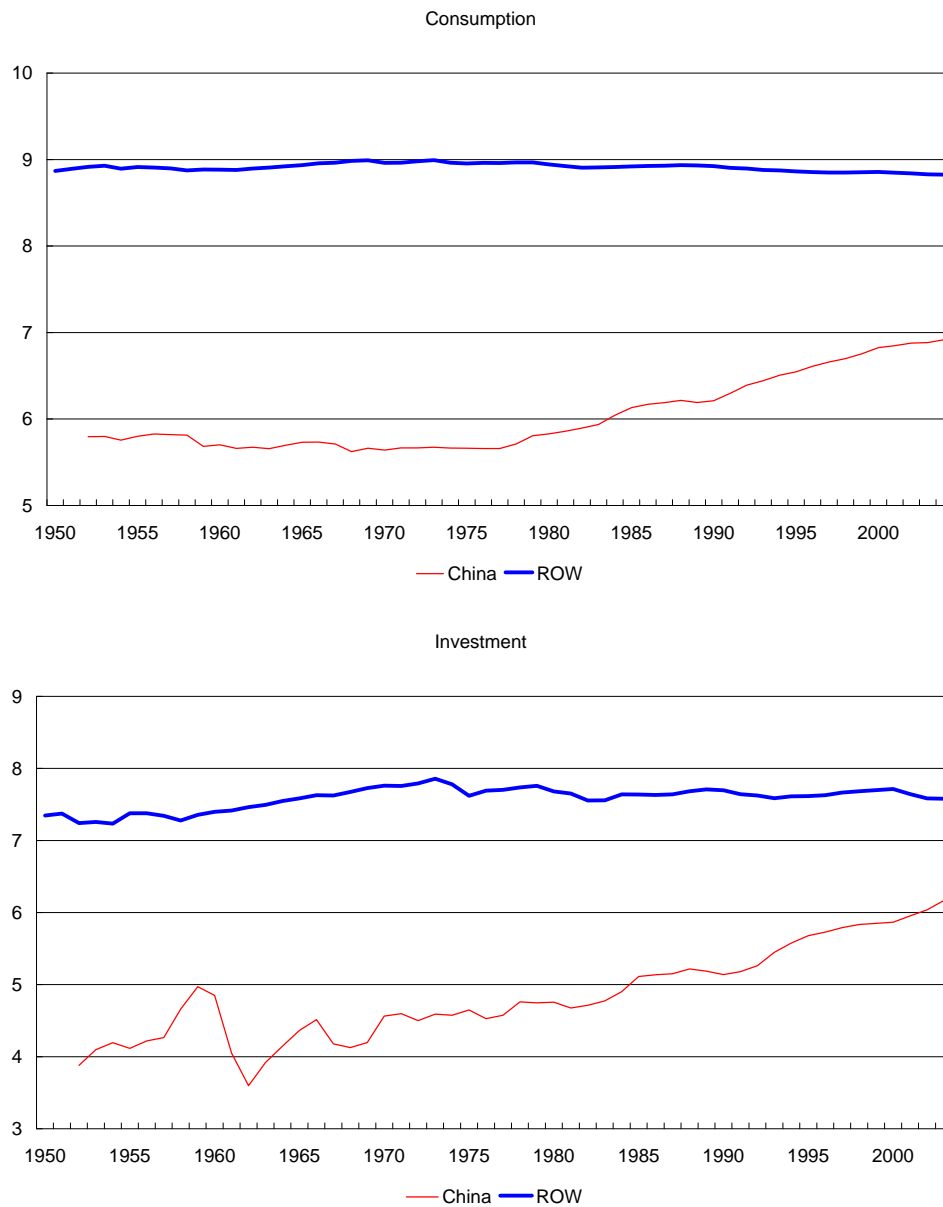


Clearly, there is no trend in the trade balance to GDP ratio prior to 1978. There are some large fluctuations in the trade balance in 1985 and 1990 and there is a persistent trade surplus in China during the 90s. The surprising fact is that while the trade volume quadrupled, trade balance to GDP ratio remained quite stable in 1978 at least in nominal terms.

## 2.4 The Demand Side

Figure 4 presents the GDP components. Consumption per EAP includes private and government final consumption expenditure. Investment per EAP includes private and government fixed investment. Both of these series are linearly detrended with the same rate as GDP per EAP.

Figure 4. GDP Components



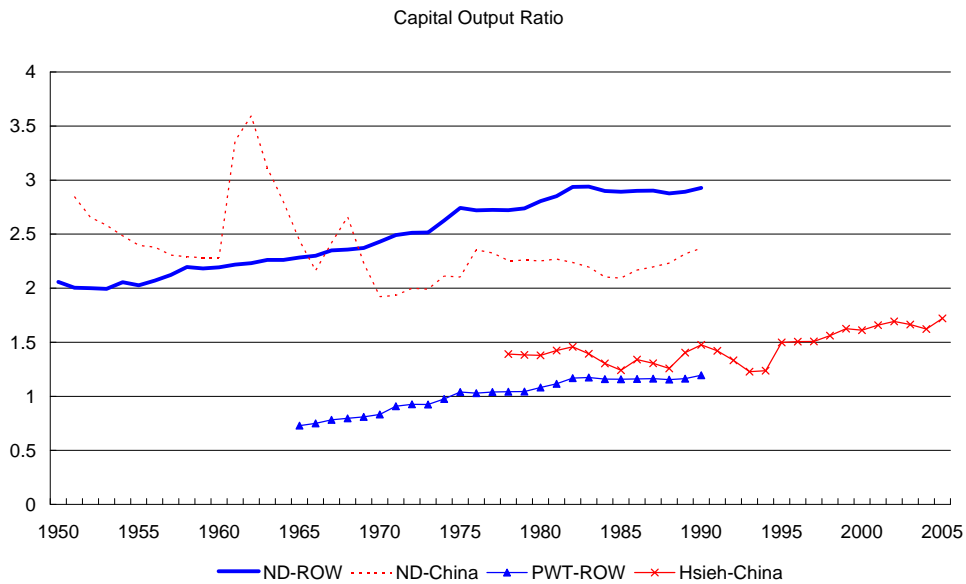
Clearly, Chinese consumption took-off in 1978 as GDP did whereas the trend break in investment is some what less obvious. The interesting point is that there is no correlation between consumption in China and ROW. In a two-country one-good model, consumption in both countries should grow at

the same rate<sup>3</sup>. This implies that there must have been changes in relative prices between goods in China and the ROW.

## 2.5 The Supply Side

Figure 5 provides estimates of capital output ratios and data on labor. Capital output ratio is computed from data either in PPP adjusted real terms or in local real prices depending on the dataset<sup>4</sup>. Labor stands for the number of people employed divided by EAP.

Figure 5. Production Factors



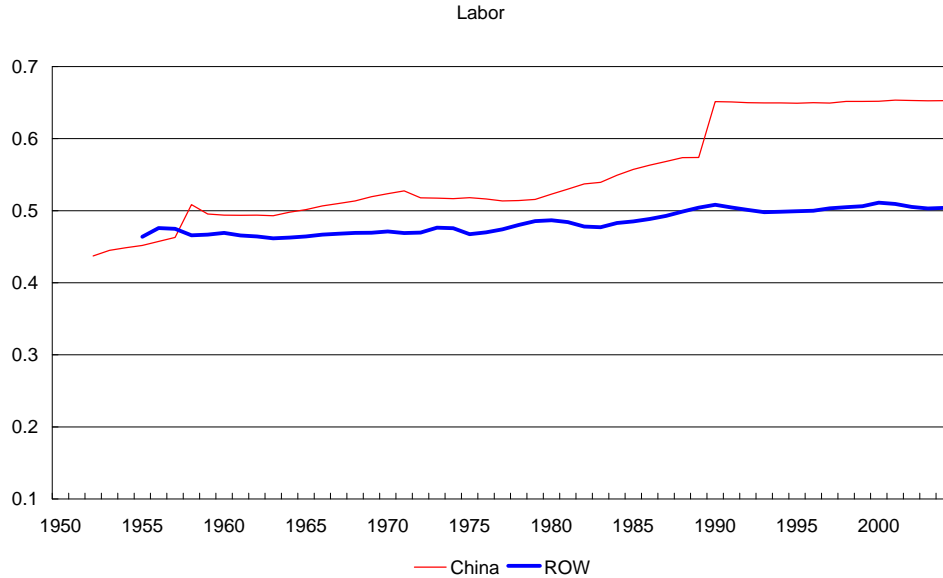
<sup>3</sup>For instance, if the periodical utility function is in the form such as the following,

$$u = \Psi \log c_t + (1 - \Psi) \log(1 - l_t)$$

there should be perfect correlation between consumption growth in both countries without any frictions.

<sup>4</sup>For the Nehru and Dhareshwar (1993) data, the ROW series is a population weighted average of capital-output ratios. For Penn World Tables, since the variables are in the same unit, the ROW series is simply the sum of capital stock divided by the sum of output. For the Bai et al (2006) data, we use the investment goods deflator to compute the real capital to GDP ratio.





We plot capital stock estimation from several sources. Nehru and Dhareshwar (ND(1993)) reports real capital stock in 1987 local prices. According to the ND estimates, the average capital-output ratios over the 1950-1990 period are 2.5 in the ROW and 2.4 in China. Another widely used source is PWT 5.6 which reports capital stock per worker in 1985 international dollars<sup>5</sup>. According to PWT, the capital-output ratio for the 1965-1990 period in the ROW is 1.01. However, it does not report capital stock estimates For China. Bai, Hsieh and Qian (2006) reports nominal capital-output ratio in China over the 1978-2005 period. Adjusting for relative prices, the average real capital-output ratio in 1978 yuan is 1.45. According to ND, the capital-output ratio in China is similar to that in the ROW. Also, according to both ND and Bai, Hsieh and Qian (2006), recently the capital-output ratio is quite stable. However, the ratio depends on the currency unit used and the base year.

Usually labor refers to total hours worked which consists of hours worked per worker and the number of workers employed. However, data on hours worked is not available in China and several ROW countries. Thus, we use the civilian employment data from OECD as a proxy for labor<sup>6</sup>. Employment

<sup>5</sup>PWT uses the Heston-Summers method for PPP adjustment. They have not yet updated the capital per worker series in version 6.1.

<sup>6</sup>For France, we use the LABORSTA data base from International Labor Organization.

per EAP in the ROW is roughly stable and slightly increases throughout the period. On the other hand, employment per EAP in China increases with a jump in 1990.

Given estimates of capital stock and data of output and labor, we can compute a crude measure of aggregate TFP from a production function

$$Y_t = K_t^\theta (A_t l_t)^{1-\theta}$$

where  $\theta$  is the capital share,  $A_t^{1-\theta}$  is aggregate TFP and  $Y_t$ ,  $K_t$  and  $l_t$  are output, capital and labor per EAP. The measure is “crude” in several aspects. First, as shown above, there are discrepancies in the capital stock data across datasets. We construct the capital stock series using the capital-output ratio in 1952 from ND and the perpetual inventory method assuming a 3.5 percent depreciation rate in both countries<sup>7</sup>. Second, as mentioned above, data on hours worked per worker is not available. Since we use the employment data as a proxy for total hours worked (labor), our measure of aggregate TFP includes changes in hours worked per worker. Finally, whereas we assume standard Cobb-Douglas production functions for both the ROW and China, capital shares might differ across countries. This is especially problematic in aggregating TFP for the ROW. Following Gollin (2002), we use one-third as a common capital share for the ROW and China and thus avoid this issue.

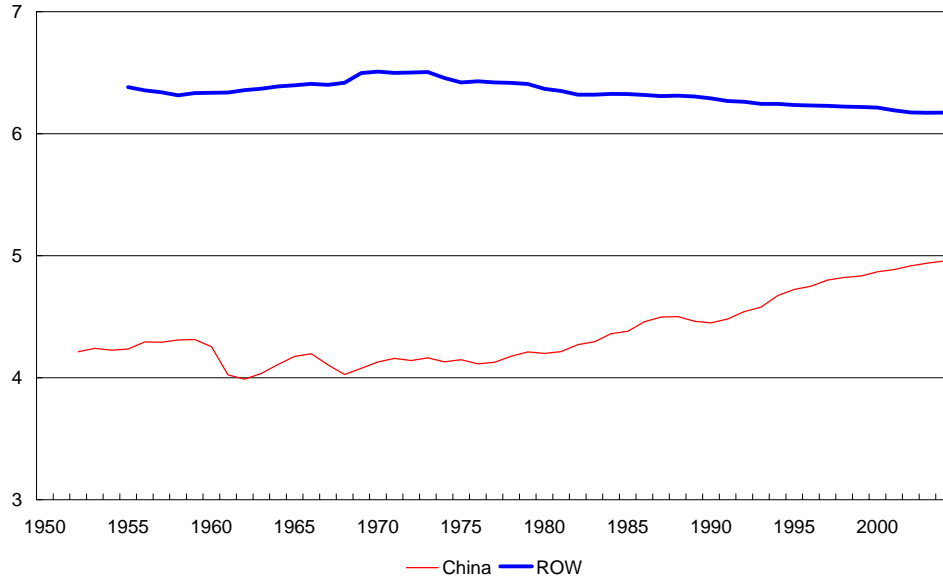
Figure 6 plots our measure of aggregate TFP detrended with the same linear trend as in figure 2. We can clearly see that the take-off of Chinese output coincides with a take-off of aggregate TFP. The average growth rates of TFP in the ROW and China were 2.7 percent and 2.3 percent During the 1952-1977 period and 1.1 percent and 7.0 percent during the 1978-2003 period respectively<sup>8</sup>. The amazing coincidence in the opening and the take-off implies that there might be a common source of these two. In this paper, we do not explore the sources of aggregate TFP growth. Instead, we deduce the quantitative impacts of a sudden growth in technology on the Chinese and the ROW economies.

---

<sup>7</sup>This gives 3.2% for ROW and 3.75% for China. For convenience, we choose 3.5% as the common depreciation rate.

<sup>8</sup>The ROW series starts from 1955 due to the lack of employment data.

Figure 6. “Crude” Measure of TFP



In short, the three key features of the Chinese economy are: (1) China suddenly opened-up in 1978, (2) output growth took-off in 1978 and (3) although the trade volume increased, there seems to be no trend in the trade balance. In the following section, we consider a dynamic stochastic general equilibrium model incorporating these three features.

### 3 Backus, Kehoe and Kydland Economy

The basis of our model is a competitive market version of a two-country two-good model à la Backus, Kehoe and Kydland (1994)<sup>9</sup>. The two countries in the economy are China and the ROW. Intermediate goods produced from capital and labor in each country are traded in the international good market. The terms of trade is defined as the relative price of the two. Labor and capital are internationally immobile. Final goods in each country are produced from these intermediate goods. The countries can also trade state-contingent international claims in a complete asset market. The model is detrended with constant TFP growth in order to induce stationarity.

<sup>9</sup>The competitive setting follows Raffo (2006).

### 3.1 Household

We assume that representative households in both economies ( $i = C, R$ ) gain utility from consumption and leisure. The preference is a standard Cobb-Douglas function for each household. The households maximize their lifetime utility:

$$U_i = \sum_t \beta^t (\Psi_i \log c_{i,t} + (1 - \Psi_i) \log(1 - l_{i,t})) \quad (1)$$

subject to budget constraints:

$$w_{i,t}l_{i,t} + r_{i,t}k_{i,t} + T_{i,t} + rer_{i,t}d_{i,t} = c_{i,t} + x_{i,t} + rer_{i,t}Q_t\Gamma d_{i,t+1}. \quad (2)$$

That is, the households receive income from labor  $l_{i,t}$ , capital  $k_{i,t}$ , lump-sum transfer  $T_{i,t}$  as well as the return from the claim  $d_{i,t}$ , and spend it on consumption  $c_{i,t}$ , investment  $x_{i,t}$  and claims for the next period  $d_{i,t+1}$ . As mentioned below, there is lump-sum transfer only in China. The price of international claims  $Q_t$  is common to both countries<sup>10</sup>. International claims are denominated in the ROW currency, so claims holdings must be adjusted for the real exchange rate  $rer_{C,t}$  in China, whereas  $rer_{R,t} = 1$ . All prices are in real terms relative to the price level of final goods in each country. We assume that the population growth rate  $n$  and the growth rate of technology on the world frontier  $\gamma$  are constant and define  $\Gamma = (1 + \gamma)(1 + n)$  in order to adjust for the trend. Investment is defined by the capital accumulation equation:

$$\Gamma k_{i,t+1} = (1 - \delta)k_{i,t} + x_{i,t}. \quad (3)$$

### 3.2 Intermediate Good Firm

The representative intermediate good firms in each country specialize in producing goods  $a$  and  $b$  respectively. The firms produce intermediate goods from labor and capital using a constant returns to scale technology:

$$y_{i,t} = \exp(z_{i,t})k_{i,t}^\theta l_{i,t}^{1-\theta} \quad (4)$$

where  $z_{i,t}$  is TFP of the intermediate goods firm which we refer to as “productivity” in order to distinguish it from aggregate TFP. Intermediate good

---

<sup>10</sup>The model is deterministic and the international claim is a redundant asset.

firms maximize profits defined as the value of production  $p_{i,t}^j y_{i,t}$  net of labor and capital costs:

$$\max \pi_t = p_{i,t}^j y_{i,t} - w_{i,t} l_{i,t} - r_{i,t} k_{i,t}$$

where  $p_{i,t}^j$  are the prices of intermediate goods ( $j = a, b$ ) produced in each country relative to the final good price in the corresponding country.

### 3.3 Final Good Firm

The representative final good firms in each country produce final goods from intermediate goods using an Armington aggregation technology:

$$\begin{aligned} G_{C,t}(a_{C,t}, b_{C,t}, \eta_{C,t}) &= \left( \eta_{C,t} a_{C,t}^{\frac{\varepsilon-1}{\varepsilon}} + (1 - \eta_{C,t}) b_{C,t}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}. \quad (5) \\ G_{R,t}(a_{R,t}, b_{R,t}, \eta_{R,t}) &= \left( (1 - \eta_{R,t}) a_{R,t}^{\frac{\varepsilon-1}{\varepsilon}} + \eta_{R,t} b_{R,t}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \end{aligned}$$

Firms maximize profits defined as the value of production net of the cost of intermediate goods inputs. As shown in the previous section, one major event in China is the sudden opening to trade in 1978. This is a direct result of the shift in the social environment, i.e. the ‘‘Reform and Opening-up policy’’. Prior to the opening, trade was controlled by the government and was aimed to roughly balance. For simplicity, we assume that the Chinese government imposes tariffs on foreign goods in order to maintain balanced trade. Therefore, the profit maximization problem for the Chinese final good firm is

$$\max G_{C,t}(a_{C,t}, b_{C,t}, \eta_{C,t}) - p_{C,t}^a a_{C,t} - (1 + \tau_{C,t}) p_{C,t}^b b_{C,t}.$$

On the other hand, we assume that the ROW government does not impose tariff on its imports from China<sup>11</sup>. Thus, the profit maximization problem for the ROW is

$$\max G_{R,t}(a_{R,t}, b_{R,t}, \eta_{R,t}) - p_{R,t}^a a_{R,t} - p_{R,t}^b b_{R,t}.$$

---

<sup>11</sup>In the appendix, we also provide for a model in which both countries impose tariffs.

### 3.4 Government

The Chinese government fully rebates the tariffs with lump-sum transfer to the household. Thus, the government budget constraint is

$$\tau_{C,t} p_{C,t}^a b_{C,t} = T_t. \quad (6)$$

The ROW government plays no role in this model.

### 3.5 Resource Constraints

In any state of the economy, the resource constraints must hold in each market. Resource constraints for intermediate goods are:

$$a_t + \frac{1 - \pi}{\pi} a_t^* = y_{C,t} \quad (7)$$

and

$$\frac{\pi}{1 - \pi} b_t + b_t^* = y_{ROW,t} \quad (8)$$

where  $\pi$  is the EAP weight of China. The resource constraints for final goods in each country are

$$c_{i,t} + x_{i,t} = G_{i,t}(a_{i,t}, b_{i,t}, \eta_{i,t}). \quad (9)$$

The market clearing condition for claims

$$\pi d_{C,t} + (1 - \pi) d_{ROW,t} = 0$$

implies

$$\pi(p_{C,t}^a y_{C,t} - G_{C,t}) + (1 - \pi) \text{rer}_t (p_{R,t}^b y_{R,t} - G_{R,t}) = 0.$$

Since the final condition is guaranteed by the Walras' law, we do not include this in the set of equilibrium conditions when we solve the model.

### 3.6 Prices

The marginal utility of final good consumption defines the price of final goods in each country:

$$u_{cC,t} = P_{C,t}$$

$$u_{cR,t} = P_{R,t}.$$

Therefore, in equilibrium, the real exchange rate can be expressed as follows:

$$rer_t = \frac{P_{R,t}}{P_{C,t}} = \frac{p_{C,t}^a}{p_{R,t}^a} = \frac{p_{C,t}^b}{p_{R,t}^b} = \frac{u_{cR,t}}{u_{cC,t}}.$$

Also, by definition,

$$tot_t = \frac{p_{C,t}^a}{p_{C,t}^b} = \frac{p_{R,t}^a}{p_{R,t}^b}.$$

## 3.7 Exogenous Variables

### 3.7.1 Home Bias

We consider a sudden reduction in the home bias  $\eta$  in China as a key shock to the Chinese economy. We assume that the Chinese government can directly affect home bias through industrial policy. This unobservable shock is important in explaining the sudden increase in openness in 1978:

$$v_t = \frac{(1 - \pi)a_{R,t} + \pi b_{C,t}/tot_t}{\pi y_t}.$$

The home bias determines the share of home goods within the Armington aggregator to produce final goods. Since, a reduction in home bias increases the demand for imports, openness should increase as well given the balanced trade constraint.

In 1978, the Chinese government introduced a drastic import reform program. Non-tariff barriers such as quotas and import licensing regulations were reduced. At the same time, they also allowed exports from special economic zones that specialize in producing labor intensive goods. We assume that along with these trade policies, there was industrial policy which shifted in the final good production function, i.e. the Armington aggregator in China<sup>12</sup>.

### 3.7.2 Productivity

Sources of TFP growth in China is discussed in studies such as Dekle and Vandenbroucke (2006) and Young (2003). Unlike these studies, the main

---

<sup>12</sup>We conjecture that a model with export tariffs instead of variable home bias should produce similar results to our model. We believe that the reform in China was more than a simple reduction in tariffs but a shift in the social paradigm. Thus, changes in home bias seemed to be a better proxy of the reform and opening-up policy.

purpose of our paper is not to reveal the source of TFP growth, but is to deduce its impact on China and the ROW along with home bias shocks.

One accounting matter to be noted is that the intermediate goods firm productivity in our model is not equivalent to aggregate TFP introduced in the previous section. In GDP accounting sense, the value of production in country  $i$  is  $p_{i,t}^j y_{i,t}$ . Thus, aggregate TFP in each country is  $p_{i,t}^j z_{i,t}$ , which means that changes in both  $p_{i,t}^j$  and  $z_{i,t}^j$  affect aggregate TFP. In the model, we treat  $z_{i,t}^j$  as exogenous and  $p_{i,t}^j$  as endogenous.

### 3.7.3 Import Tariffs

In the previous section, we show that a key feature of the Chinese economy is the stable trade balance. We consider import tariffs as a key variable to maintain balanced trade in China. We cannot directly use tariff data in the quantitative section because of availability issues. Lardy (2002) reports tariff data over the 1982-2001 period whereas we are interested in the period before 1978. Lardy (2002) also states that tariffs did not have important effects on imports since the quantities of imports were determined by the government.

In this paper, we compute tariffs needed in order to guarantee balanced trade in the model. This way, we can compute the effective tariff rate which includes all inefficiencies in the Chinese import goods market.

## 3.8 Competitive Equilibrium

The competitive equilibrium is a set of allocations and prices for  $i = C, R$ ;  $\{c_{i,t}, b_{i,t}, k_{i,t+1}, y_{i,t}, x_{i,t}, T_{i,t}, a_{i,t}, b_{i,t}, w_{i,t}, r_{i,t}, p_{i,t}^a, p_{i,t}^b, z_{i,t}, \eta_{i,t}, \tau_{i,t}\}_{t=0}^{\infty}$  such that, (1) household optimizes given  $\{w_{i,t}, r_{i,t}, T_{i,t}\}_{t=0}^{\infty}$  and  $k_{i,0}$ , (2) intermediate goods firms optimize given  $\{w_{i,t}, r_{i,t}, p_{i,t}^j, z_{i,t}\}_{t=0}^{\infty}$ , (3) final goods firms optimize given  $\{p_{i,t}^a, p_{i,t}^b, \eta_{i,t}, \tau_{i,t}\}_{t=0}^{\infty}$ , (4) markets clear, (5) the Chinese government budget constraint (6) holds and (6) the resource constraints hold.



## 4 Quantitative Analysis

### 4.1 Parameter Values

We assume the EAP weight to be constant at  $\pi = 1/2$ <sup>13</sup>. The original literature solves a social planner's problem so this parameter shows up as Negishi Pareto weights. However, in the competitive market problem we solve, this is simply the weights of EAP which shows up in the resource constraints of intermediate goods.

We set the shock persistence arbitrarily high so that the shock process is almost unit root. The elasticity of substitution between home goods and foreign goods  $\varepsilon$  is borrowed from Backus, Kehoe and Kydland (1994). The capital depreciation rate  $\delta$  is determined as mentioned. The discount factor  $\beta$  and the consumption-leisure parameter  $\Psi$  are calibrated to roughly match data for the steady state capital output ratio 2.5 and the steady state labor level 0.3<sup>14</sup>.

For simplicity, we assume a symmetric steady state such that  $\eta_C = \eta_R = \eta$ ,  $a_C = b_R$ ,  $a_R = b_C$ ,  $tot = 1$  and  $\tau = 0$ . The steady state home bias  $\eta$  depends is determined by the symmetric steady state terms of trade:

$$tot = 1 = \frac{\eta}{1 - \eta} \left( \frac{b_C}{a_C} \right)^{\frac{1}{\varepsilon}}.$$

This depends on on the steady state export to import ratio:

$$\frac{a_C}{b_C} = \frac{1 - b_C/y_C}{b_C/y_C}$$

where  $b/y$  is the steady state import share to production. Thus, the import share determines the degree of home bias  $\eta$ . We assume steady state import share of 0.15 following Backus, Kydland and Kehoe (1994), which implies the steady state openness equals to 0.3.

Table 1 presents the parameter values.

---

<sup>13</sup>In the data, this ranges from 0.58 to 0.64. For simplicity, we assume 0.5. Raffo (2006) shows that the country size does not affect the equilibrium allocation for a given export share.

<sup>14</sup>Steady state capital-output ratio around 2.5 roughly matches the N-D data for both countries. Steady state labor around 0.3 implies a Frisch elasticity of labor supply of 2.33 given log preferences, which is standard in the business cycle literature.

Table1. Parameter Values

	China	ROW
$\pi$	0.5	0.5
$\varepsilon$	1.5	1.5
$\delta$	0.035	0.035
$\beta$	0.95	0.95
$\Psi$	0.34	0.34
$\eta$	0.71	0.71
$\theta$	1/3	1/3

## 4.2 Simulation

In this section, we solve a deterministic version of our model in order to obtain the nonlinear equilibrium paths of endogenous variables given exogenous changes in home bias and productivity. Since both home bias and productivity are not directly observable, we choose them such that the endogenous Chinese output and openness roughly match the data. In specific, we assume that the openness and detrended growth rate were 10% and 0% prior to 1978 and 30% and 5% after 1978. We set the post-1978 openness constant at 30% since this is the value implied by the symmetric steady state in section 3<sup>15</sup>.

Since we use a deterministic model, the paths of exogenous variables are perfectly foreseen. Assuming that the Chinese agents knew that the opening-up and reform policy would occur in 1978 beforehand does not seem reasonable. Thus, we divide the period into two. The first period is illustrated by low GDP and openness in China. The second period starts at 1978 in which suddenly home bias dropped and productivity started to grow. This setting implies that the agents were suddenly surprised by the new path of exogenous variables and reoptimized in 1978<sup>16</sup>.

First, during the 1950-1977 period, we set the level of productivity such that Chinese GDP is roughly 5% relative to the ROW GDP. It turns out that with this level of productivity, the symmetric steady state level of home bias produces openness roughly equal to 10%<sup>17</sup>. Next, in 1978, we introduce

<sup>15</sup>This is lower than the observed level in chapter 2, however, the openness in chapter 2 includes trade against the whole world whereas our model only deals with the G7 countries.

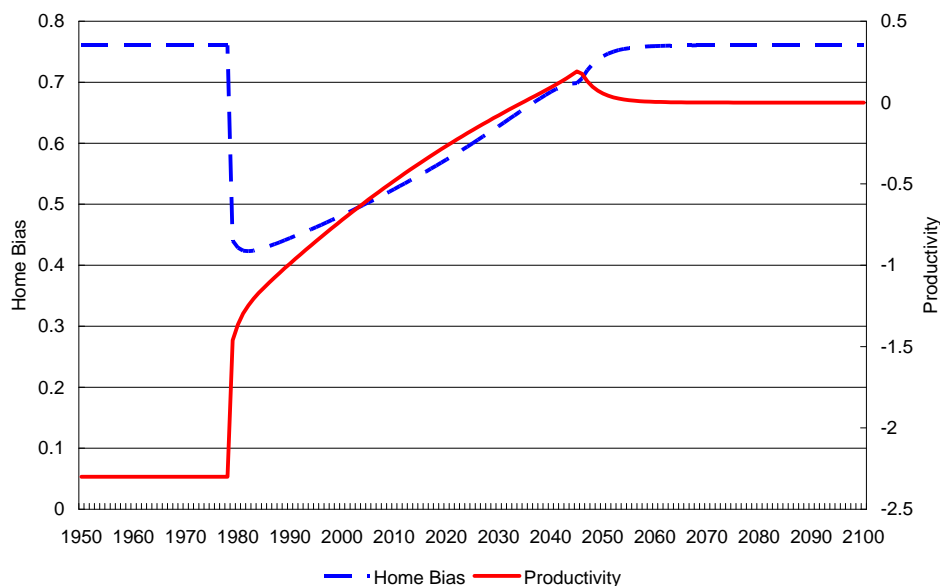
<sup>16</sup>This is the same setting as the sudden surprise exercise in Meza and Quintin (2007) and Kehoe and Ruhl (2007).

<sup>17</sup>It is well known that smaller countries have higher trade shares. Thus, this initial home bias level should be considered high given China's degree of development prior to the

a drop in home bias so that openness suddenly increases. Finally, we set a path of productivity growth and home bias during the 1978-2100 period such that the Chinese openness remains around the 30% level and detrended GDP grows roughly at the 5% level. We extrapolate from 2004 assuming that Chinese output continues to grow by 5% until it converges to the ROW level<sup>18</sup>. This procedure is related to the business cycle accounting method introduced by Chari, Kehoe and McGrattan (2007).

Figure 7 shows the computed exogenous variables. The home bias suddenly drops as expected. Productivity initially jumps up and then gradually grows. In the following, we simulate the model with each shocks separately in order to analyze the effects of each shocks, and then we discuss the overall effect of both shocks. For all simulations, we assume balanced trade holds throughout all periods.

Figure 7. Exogenous Variables



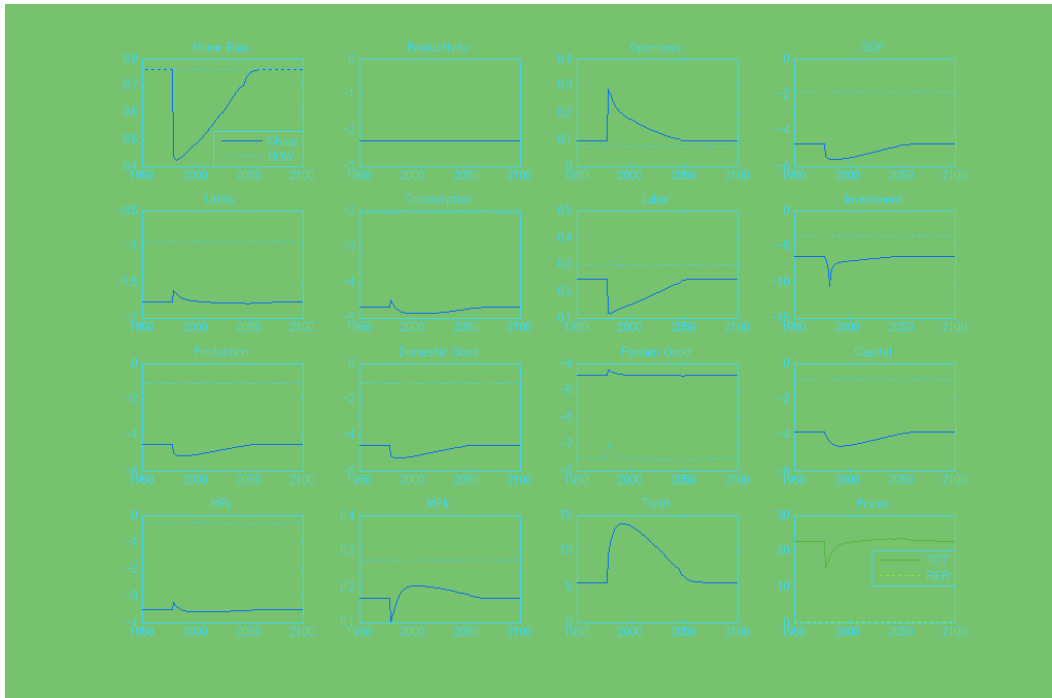
opening.

<sup>18</sup>Changing the speed of convergence does not affect the result. We can alternatively use a smoother path of convergence for the 2004-2100 period.

### 4.2.1 Simulation with Home Bias

In order to explain the sudden jump in openness, home bias must fall in 1978. Figure 8 shows the results of the simulation with home bias shocks and constant productivity. All growing variables are expressed in log deviations from their long run steady states. Home bias, openness and labor are expressed in levels.

Figure 8. Simulation Results with Home Bias Shocks



The sudden reduction in Chinese home bias causes a fall in the world relative demand for good  $a$ . Since the demand for home goods fall, China will produce less. Thus, in China both labor and investment fall and capital stock falls following the drop in investment. Consumption initially increases since the trade account remains balanced while investment falls more than output. Consumption gradually falls following the decline in capital stock. As home bias returns to the steady state, both labor and capital stock return to the steady state. As a result, Chinese utility is higher in the short run and becomes slightly lower in the medium run relative to the initial level. As the home bias returns to the initial level, the economy goes back to the initial

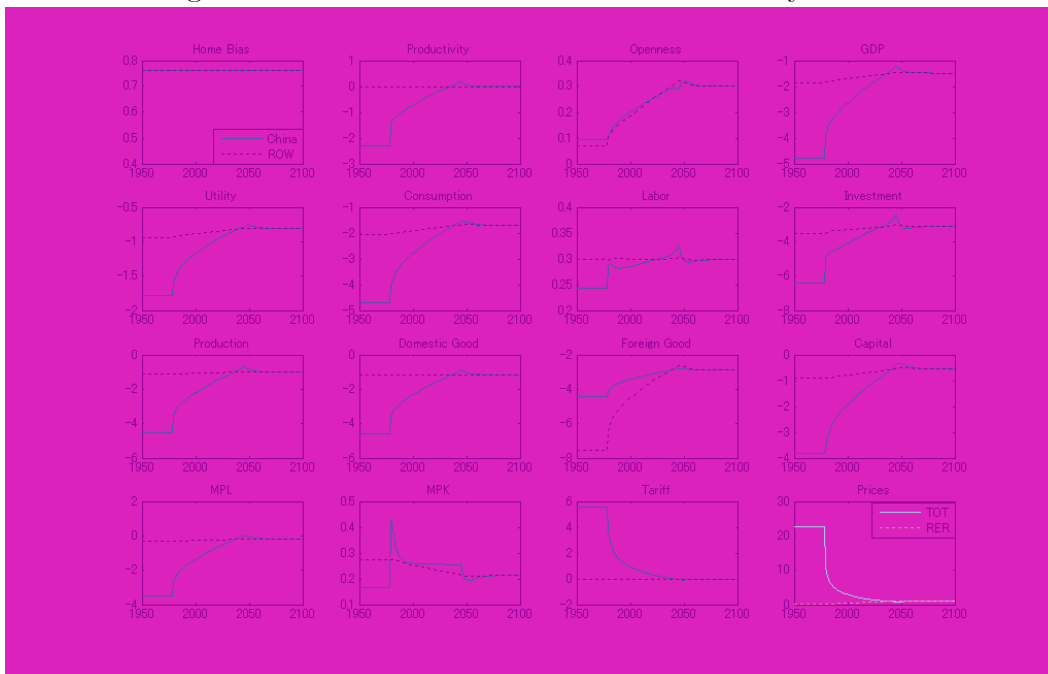
level. One notable result is that Chinese labor does not end up in the steady state level. Usually, a permanent change in productivity does not affect the amount of labor. However, in our model the terms of trade is affected by the long run productivity level through the balanced trade constraint, which in turn affects the level of labor.

In the ROW, since the world relative demand for  $b$  increases, this is a positive shock for production. The ROW will increase labor and investment in order to produce more. Also, the instantaneous improvement in the terms of trade causes a positive income effect in the short run. Thus, consumption increases. Since consumption and labor both increase, the total effect on utility is ambiguous. The effect of this shock is small in the ROW since China is small relative to the ROW.

#### **4.2.2 Simulation with Productivity**

In order to explain the gradual growth in China after 1978, productivity must increase. In fact, productivity initially jumps up and then gradually grows. Figure 9 shows the simulation results of the model with only productivity shocks.

Figure 9. Simulation Results with Productivity Shocks



As in a standard neoclassical optimal growth model, an increase in productivity causes Chinese output, labor, investment and consumption to increase. Chinese labor ends up in the steady state level since the price distortion vanishes in the long run as productivity approaches the steady state level. Utility is constantly growing as productivity increases.

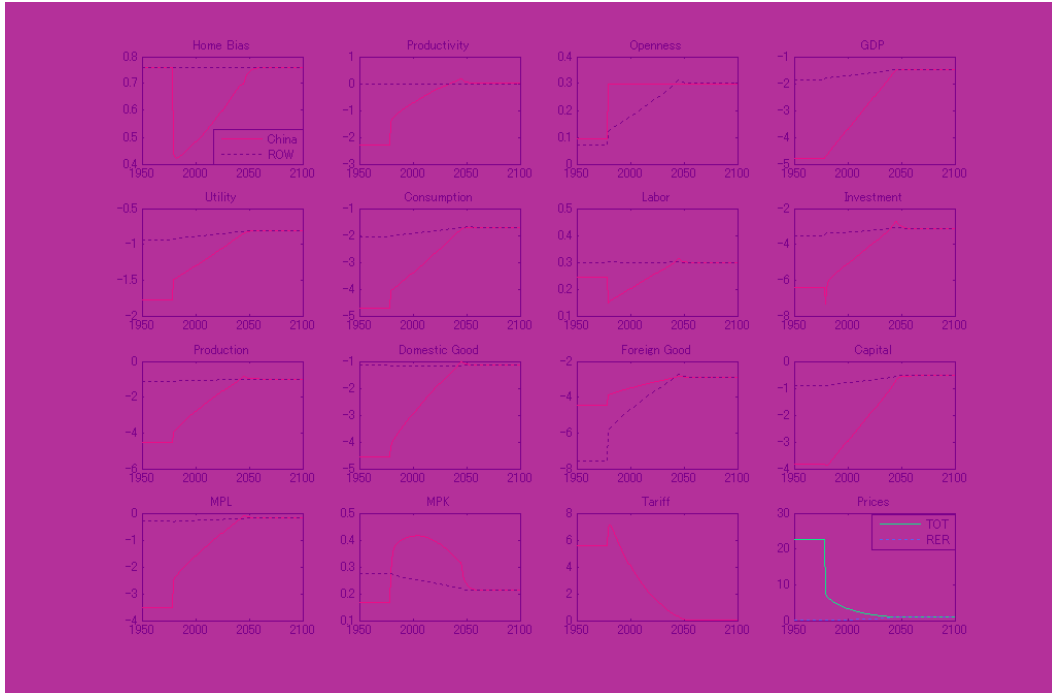
The ROW is affected by Chinese productivity growth even though the ROW productivity is not affected. The main channel through which Chinese productivity growth affects the ROW is the terms of trade. As Chinese productivity increases, the relative price of good  $a$  falls. This is a positive terms of trade shock to the ROW where his products are more profitable and foreign products are more affordable. The ROW produces more and at the same time consumes more. Thus, consumption and labor both increase.

#### 4.2.3 Simulation with Home Bias and Productivity

Figure 10 shows the results to the deterministic simulation with both shocks. In order to explain the jump in openness in 1978, the home bias must jump

down. However, since a jump down in home bias reduces Chinese GDP, productivity must jump up in 1978 to counter this effect. After 1978, productivity gradually grows such that GDP grows 5% each year. Since productivity growth increases openness, home bias must increase in order to maintain openness at the 0.3 level.

Figure 10. Simulation Results with Both Shocks



In China, the effect of productivity growth dominates the effect of the home bias shocks in terms of utility. That is, China is better off both in the short run and in the medium to long run. In the ROW, productivity growth is the dominant shock as well. As a result, both economies are better off.

#### 4.2.4 Welfare Analysis

Table 2 presents the welfare improvement in each country given the shocks. Welfare improvement is defined as the difference between the 1978 present value of the household's lifetime utility given the shocks and that without the shocks over the 1978-2004 period. It turns out that with only home

bias shocks, China is better off. This implies that the short run effect of labor drop dominates the long run effect of consumption decline. On the other hand, the impact of Chinese Home bias shocks on the ROW is very small. Both China and the ROW are better off due to the growth in Chinese productivity. The over all effect shows that both China and the ROW are better off due to the opening-up and growth of China.

Table 2. Welfare Analysis

	$\eta_C, z_C$	$\eta_C$	$z_C$
China	8.31	0.95	9.52
ROW	0.82	0.03	0.84

Finally, regarding the discrepancy of the model prediction and the data, we propose several adjustments. Some variables such as investment, labor and consumption in China directly inherit the jumps in home bias and productivity shocks in 1978. Investment and labor adjustment costs and habit formation in consumption might be a sensible way to account for this discrepancy. Also, the model predicts gradual growth in detrended output, consumption and investment in the ROW, which did not occur in reality. In the simulation we set the ROW productivity constant. If the ROW productivity slightly fell, this would counter the positive effect of Chinese productivity growth<sup>19</sup>. We do not adjust for these issues in order to make our model as simple as possible.

## 5 Conclusion

In this paper, we assess the global impact of the Chinese opening-up and growth within a standard neoclassical two-country two-good framework. We show that a sudden drop in home bias and gradual productivity growth in China can account for the sudden increase in openness and rapid output growth in China. We find that the home bias shock per se is welfare improving for China while its impact on the ROW is small. We also find that productivity shocks are welfare improving for both China and the ROW. Thus, we conclude that the Chinese reform and opening-up policy was welfare improving for both economies if it led to significant productivity growth.

<sup>19</sup>Indeed the crude TFP measure is decreasing in the ROW. This leads us to believe that productivity in the ROW may have been falling recently.



Since we focus on the impact of shocks on China and the ROW, we do not model the source of productivity growth and take it as exogenous. Future study should aim to reveal the relationship between the opening-up and productivity growth in China. One way to model this relationship is to assume that opening-up removed the technological barrier between the ROW and China, and led to gradual TFP growth in China as in Parente and Prescott (1994) and Eaton and Kortum (1997). Alternatively, if the import goods from abroad convey cutting-edge technology, the increase in imports itself causes productivity growth. Increased competition due to the opening-up may have also played a role in productivity growth. In any case, we consider our model as a foundation to understand the impact of Chinese growth.

## References

- [1] Backus, D., P. Kehoe and F. Kydland (1994) “Dynamics of the Trade Balance and the Terms of Trade: The J-Curve?” *American Economic Review* 84 (1), 84-103.
- [2] Bai, C., C. Hsieh and Y. Qian (2006) “the Return to Capital in China” *Brookings Papers on Economic Activity* 2.
- [3] Baxter, M. and M. Crucini (1994) “Business Cycles and the Asset Structure of Foreign Trade” NBER Working Paper 4975.
- [4] Chari, V.V., P. Kehoe and E. McGrattan (2007) “Business Cycle Accounting”, *Econometrica*, 75 (3).
- [5] Dekle, R. and G. Vandenbroucke (2006) “A Quantitative Analysis of China’s Structural Transformation”, mimeo, University of Southern California.
- [6] Gollin, D. (2002) “Getting Income Shares Right” *Journal of Political Economy* 110 (2), 458-474.
- [7] Hsieh, C. (2002) “What explains the industrial revolution in East Asia? Evidence from factor markets” *American Economic Review*, 92, 502-526.
- [8] Islam, N., E. Dai and H. Sakamoto (2002) “Role of TFP in China’s Growth” *Asian Economic Journal*, 20 (2), 127-159.

- [9] Kehoe, T. and K. Ruhl (2005) “Sudden Stops, Sectoral Reallocation and the Real Exchange Rate”, mimeo University of Minnesota.
- [10] Lardy, N., (2002) *Integrating China into the Global Economy*, Washington D.C., Brooking Institution Press.
- [11] Meza, F and E. Ouintin (2007) “Factor Utilization and The Real Impact of Financial Crises”, *Advances in Macroeconomics*, 7 (1).
- [12] Nehru, V. and Ashok Dhareshwar (1993) “A New Database on Physical Capital Stock: Sources, Methodology and Results” *Rivista de Analysis Economico*, 8 (1), 37-59.
- [13] Raffo, A. (2006) “Net Exports, Consumption Volatility and International Business Cycle Models” Federal Reserve Bank of Kansas City Research Working Paper 06-01.
- [14] Shirk, S. (1994) *How China Opened Its Door: The Political Success of the PRC’s Foreign Trade and Investment Reforms*, Washington D.C., Brooking Institution Press.
- [15] Young, A. (2003) “Gold into Base Metals: Productivity Growth in the people’s Republic of China during the Reform Period” *Journal of Political Economy* 111 (6), 1220-1261.

## A Tax War Model

Instead of home bias shocks, we can model shocks to tariffs in both countries as the driving force of sudden changes in trade volume. The modification is straight forward such that now both governments impose tariffs on imported inputs. Hence, the final good firms' problems in the ROW is

$$\max G_{ROW,t}(a_{ROW,t}, b_{ROW,t}) - \tau_{ROW,t} p_{ROW,t}^a a_{ROW,t} - p_{ROW,t}^b b_{ROW,t}.$$

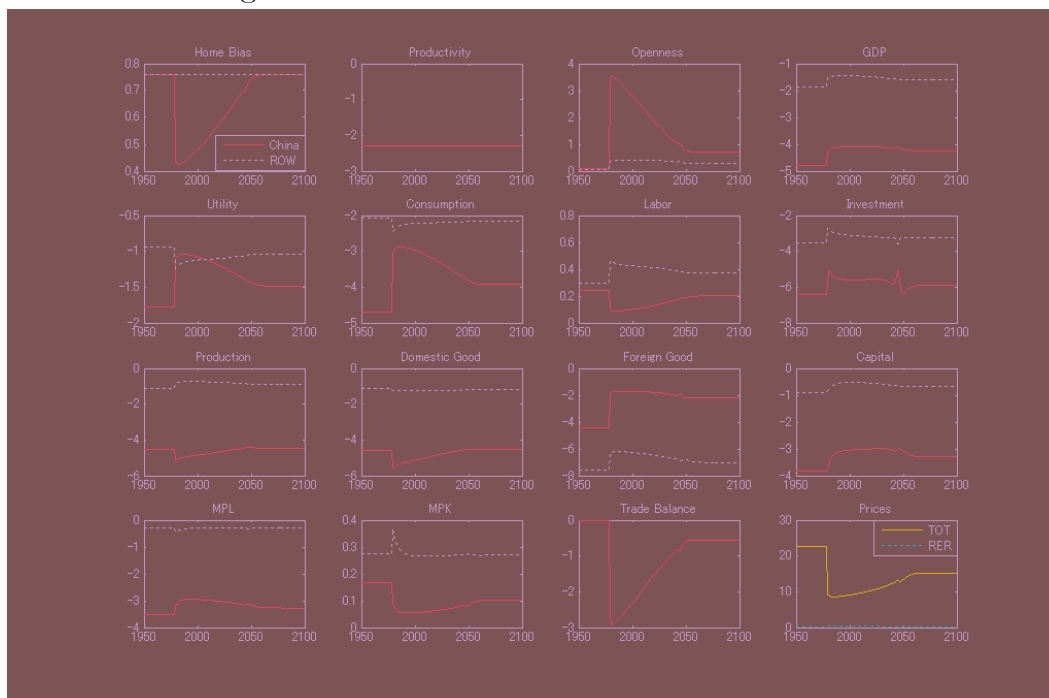
We assume that the ROW initially imposes high tariffs on imports such that trade volume is low. The Chinese tariffs are determined endogenously such that trade is virtually balanced before the opening. Once China is accepted in the international market, tariffs imposed by the ROW dramatically declines. This increases the trade volume. This model can generate similar results as the model presented above. Nonetheless, it seems more sensible to model the initiating shock within the Chinese economy.

## B Simulation with $\tau = 0$

In this section we consider a case in which the Chinese government does not impose a balanced trade constraint after the opening-up. For this counterfactual exercise, we use the same initial states assuming that trade was balanced until 1977.

First, we consider the effects of home bias on the economy. Figure A1 shows the results of the simulation with home bias alone.

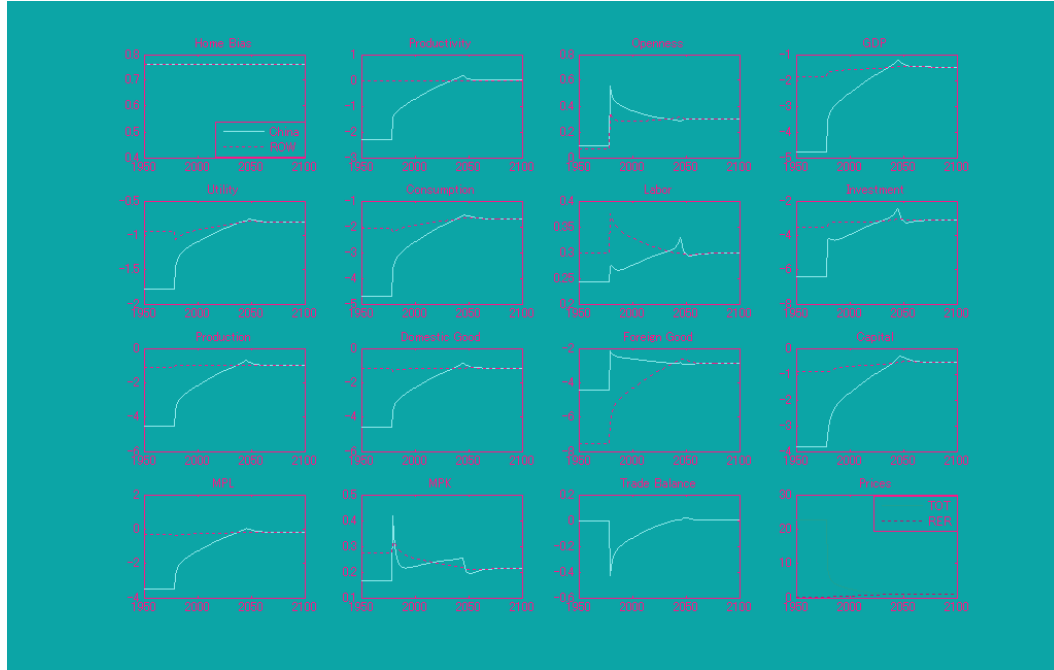
Figure A1. Simulation Results with Home Bias



The results show that China is better off as a result of home bias reduction. Since the relative demand for good  $a$  decreases, Chinese work less. Also, Chinese borrow more once the trade balance constraint is relaxed. Thus they consume more. On the other hand, the ROW is worse off. Since the relative demand for good  $b$  increases, they work more. They choose to lend and consume less. Thus, they are worse off compared to the initial state.

Figure A2 shows the simulation results with productivity.

Figure A2. Simulation Results with Productivity



The results show that China is better off for sure as a result of productivity growth. Once the balanced trade constraint is relaxed, China borrows from the ROW running a trade deficit and increases consumption. At the same time, Chinese work more due to the increase in productivity. It turns out that the periodical utility increases for all periods. On the other hand, the world demand for good  $b$  suddenly increases so that labor and investment increases in the ROW. This makes the ROW worse off temporarily. In the long run, the steady state consumption in the ROW is higher than the initial state.

Figure A3 shows the results of the simulation with both shocks. China is unambiguously better off. The utility in the ROW initially falls and then rises above the initial state so the total effect of the shocks is ambiguous.

Figure A3. Simulation Results with Both Shocks

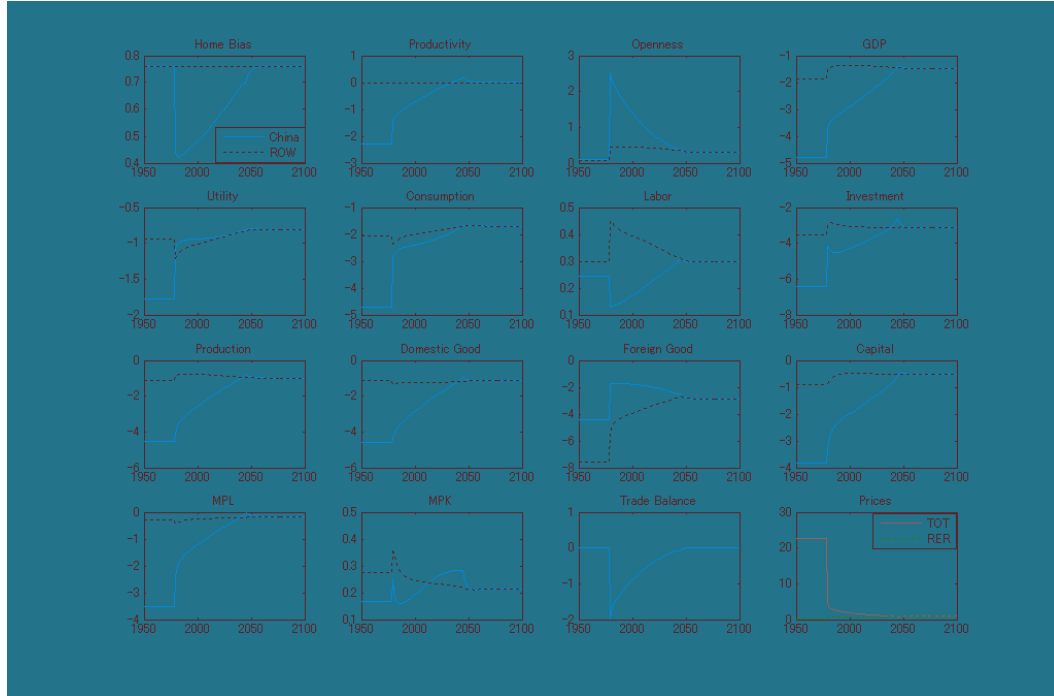


Table A1 shows the results of the welfare analysis. The results indicate that while China is better off, the ROW is worse off after home bias and productivity shocks.

Table A1. Welfare Analysis

	$\eta_C, z_C$	$\eta_C$	$z_C$
China	14.94	12.29	11.29
ROW	-1.92	-3.72	-0.21

It is surprising that the ROW is worse off even with only the productivity growth in China. Although the ROW will reach a higher level of output, capital, consumption and so on, the short run loss is so high that over all he is worse off. In addition, the total world welfare is higher than in the case when there is the balanced trade constraint. This counterfactual exercise shows that the balanced trade constraint after the opening-up is actually welfare improving from the ROW point of view.