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# The Global Impact of Chinese Growth

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Abstract

Three decades have passed since China dramatically opened up to the global market and began to catch up rapidly with leading economies. In this paper we discuss the effects of China's opening-up and rapid growth on the welfare of both China and the rest of the world (ROW). We find that the opening-up per se is welfare improving for China but has had little impact on the ROW given a balanced trade constraint. The opening-up of China is beneficial to the ROW if it leads to significant productivity growth in China. Also, China's balanced trade policy after the opening-up has helped the ROW rather than China.

**Keywords:** Productivity; Terms of Trade; Growth; Open Economy
**JEL classification:** E13, F41, O47

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# 1 Introduction

China's output growth suddenly took off in 1978. This corresponds to the sudden increase in "openness", i.e. the trade volume to GDP ratio. The rest of the world (ROW), which we define as the aggregate of the G7 countries, grew 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 leads 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 per capita GDP was around 2.5% until 1978 then jumped 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 identify 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)).

Several studies have assessed the importance of TFP in explaining the rapid growth in post-1978 China. Dekle and Vandenbroucke (2006) argued 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) claimed that the growth rate of the non-agricultural economy is "respectable but not outstanding". Islam, Dai and Sakamoto (2006) computed TFP growth with the dual approach introduced by Hsieh (2002) and found that the post-reform Chinese TFP growth was high but has recently decelerated. The main focus of these studies is China's domestic growth. There have also been studies on the impact of China's entrance into the world trade market. For instance, Coleman (2007) showed using a static model that the entrance of China caused an international production adjustment among neighbor countries through its effect on international relative prices. In this paper, we combine the two lines of literature and assess the dynamic effect of the opening-up and growth of China on the ROW within a dynamic general equilibrium setting.

The fact that the ROW did not seem to be affected by 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 PPP adjusted total GDP. In a two-country one-good model such as Baxter and Crucini (1995), there should be a high correlation between consumption growth 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 provide 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 goods weight.

The two key shocks to the Chinese economy that we assume are shocks to the weight of domestically produced intermediate goods in final goods production and the gradual productivity growth in the Chinese intermediate goods firms. The home goods weight affects the share of home goods among the total intermediate goods used to produce domestic final goods. We attribute the opening-up policy to a sudden fall in this weight, which leads to an increase in openness. Productivity growth should be important in explaining the output growth in China since there is no evidence of capital deepening during the rapid growth period, unlike in many East Asian countries. In addition to the two key shocks, we also assume a balanced trade constraint in our model. Prior to the reform in 1978, Beijing imposed several direct regulations on trade and the imports of targeted goods were financed by exports of 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 on tariffs in the context of our model is not available, we simply calculate the as-if tariffs needed to maintain balanced trade. The justification for 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. However, we do find some evidence suggesting that some sort of import restriction existed even after the opening-up.

Since we cannot directly observe the home goods weight and intermediate goods firm productivity, we deduce them by matching the openness and output in China implied from the model with a balanced trade constraint to the data. Indeed, the home goods weight suddenly drops and intermediate goods productivity growth takes off in 1978 as expected. We simulate the model given the computed values of home goods weight and productivity.

Our results show that the sudden reduction in China's home goods weight is welfare improving for China but has little impact on the ROW. On the other hand, the productivity growth in China is welfare improving for both economies. Therefore, we conclude that the opening-up policy is welfare improving for both economies if it leads to significant productivity growth. We also conduct a simulation without the balanced trade constraint and find that China would have been better off without the constraint while the ROW would have been worse off. Thus, the balanced trade constraint helps the ROW rather than China.

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

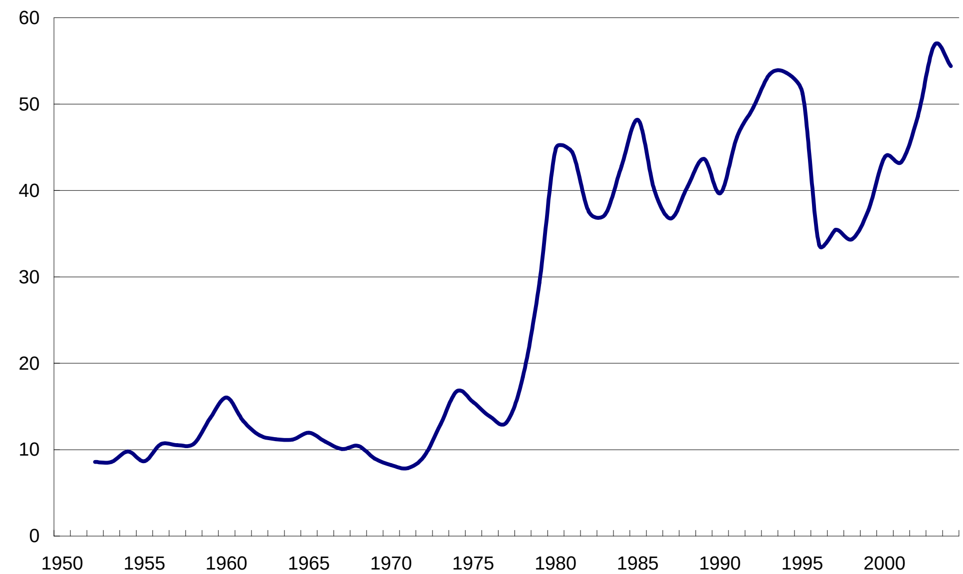
In this section, we describe the key features of the Chinese economy over the 1950-2004 period. The source of most data is from Penn World Table 6.2 and is stated otherwise.

## 2.1 Openness

Figure 1 presents the "openness" of China defined as Trade Volume/GDP in real terms[1]. 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.

[1] Note that this measure includes trade with non G7 countries as well.

Figure 1. China's Openness

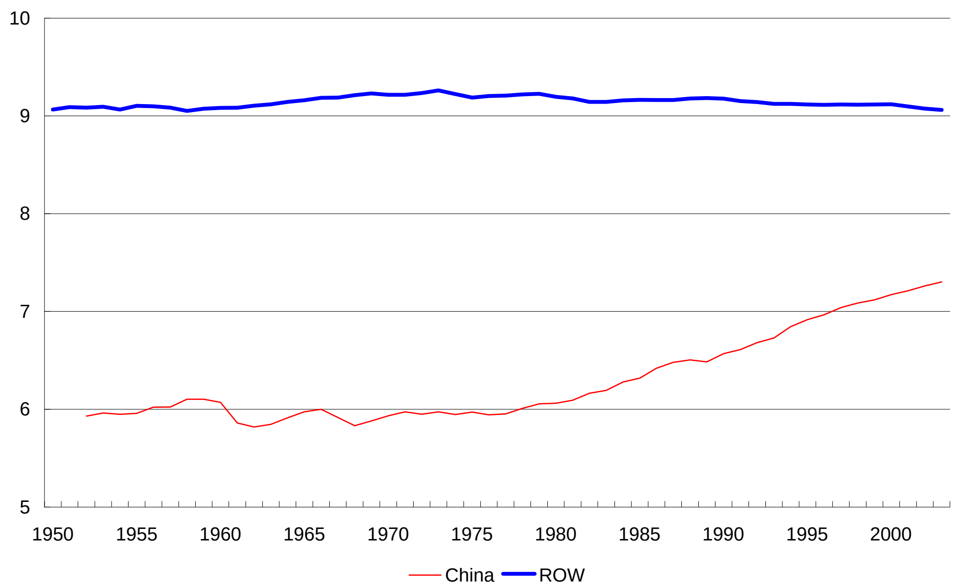



As described in Shirk (1994), the main aim of trade policy prior to 1978 was import-substitution. The government especially protected the steel and machinery industries from foreign competition by controls on imports, investment, capital flows and exchange rates. Trade was limited to the central foreign 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 economic zones and invited foreign direct investment while the number of institutions licensed to trade was dramatically increased. The opening-up not only increased trade but also changed the composition of goods traded as the economic zones started to export goods in which they had competitive advantage, namely labor intensive goods, and imports of consumer durables increased dramatically. Throughout this paper, we treat all final goods as the same and evaluate them at PPP adjusted levels following PWT 6.2.

## 2.2 Growth

Figure 2 presents GDP per economically active population (EAP)[2] in China and the 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 the ROW prior to the opening-up. Once the economy opened up, China's 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.

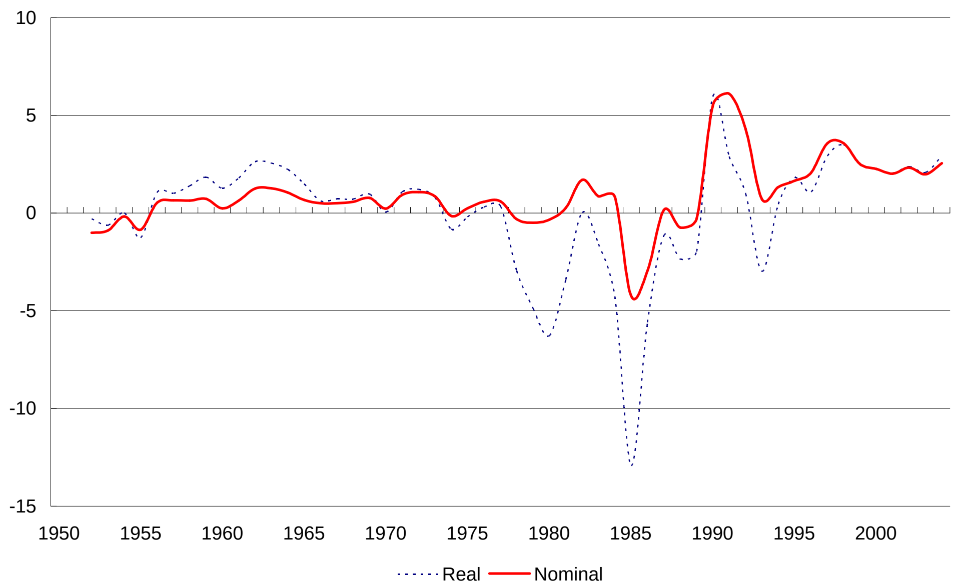
## 2.3 Trade Balance

Figure 3 presents China's real trade balance to GDP ratio. For comparison, we also provide the nominal measure which is not affected by fluctuations in price deflators. The trade balance is a tricky variable for two reasons. First, as for the openness, since we omit many countries, the trade balance of the ROW is not exactly the mirror image of the trade balance of China. Since

[2]This series correspond to GDP per worker in PWT 6.2 where PWT defines "worker" as the economically active population.

the trade balance of the ROW is not a variable in which we are interested, we focus only on China's trade balance. Second, it is tricky to convert the trade balance into real terms. One way is to simply compute it as a residual from the GDP expenditure identity using real output, consumption and investment. Another way, introduced by Feenstra, Heston, Timmer and Deng (2007), is to denominate exports and imports by their PPP adjusted weighted price indexes[3]. We follow the latter method since we are interested in the real value of trade, both the trade balance and openness, and the effects of shocks operating through the real terms of trade channel.

Figure 3. China's 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. In 1985 the government allowed trade related firms to make their own trade and production plans, which led to a sudden increase in imports of investment goods. In 1987, the government introduced an import substitution policy that immediately eliminated the trade deficit. This leads us to believe that trade

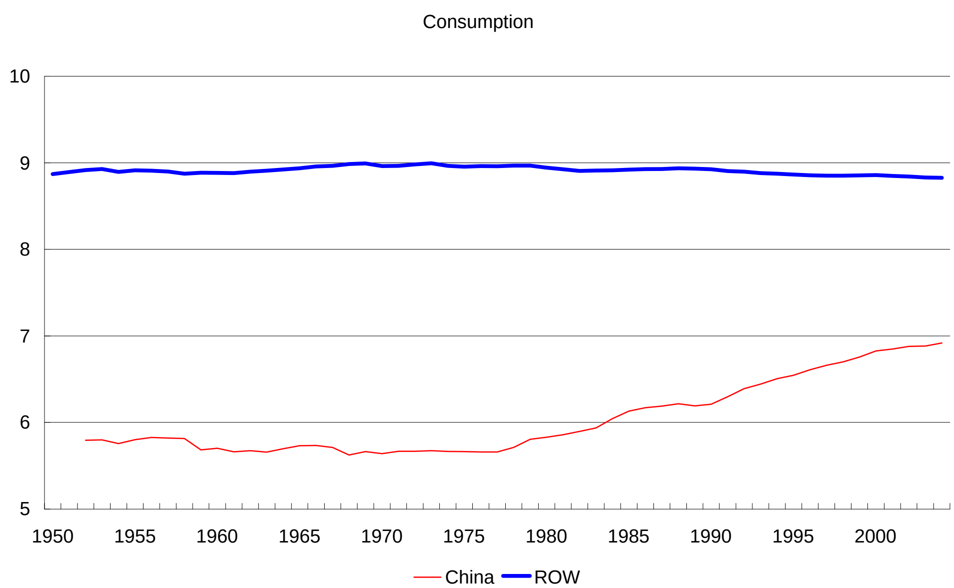
[3]Thus our measure of GDP is expenditure based PPP adjusted real GDP. The same measure of real exports and imports is used to compute real openness. A thorough discussion of this matter can be found in Feenstra, Heston, Timmer and Deng (2007).

was controlled by the government even after the opening-up. After 1994, the trade balance turned to surplus due to Chinese exchange rate control in favor of exports. This can also be considered as an indirect trade control. We do not deal with these individual episodes but instead argue that there must have been some pressure which forced trade to be almost balanced, or at least non-negative, throughout the whole period[4]. We show later in the quantitative analysis section that otherwise there would have been a large trade deficit.

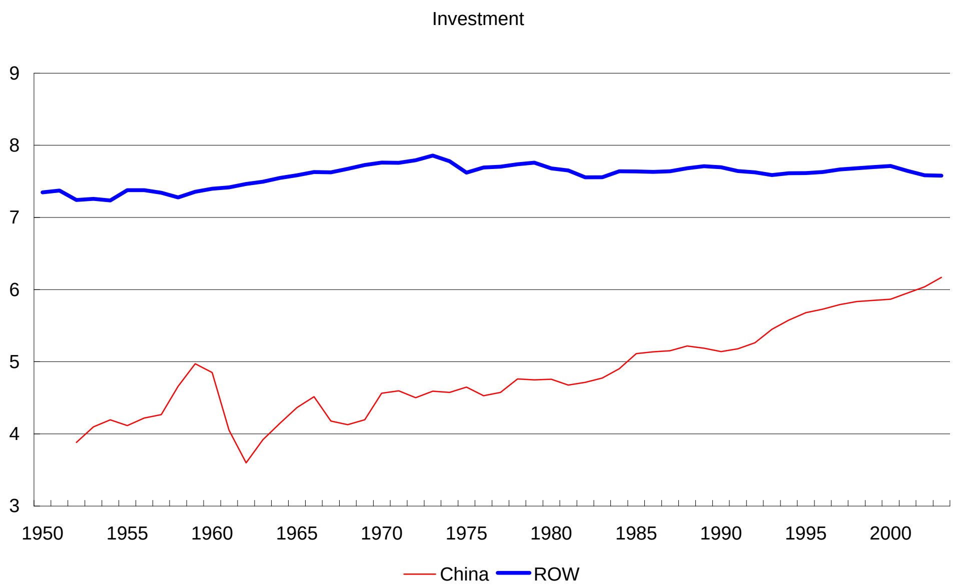
## 2.4 The Demand Side

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




[4]The huge trade surplus in 1990 seems to be merely reflecting the mild recession in 1988-89 which most likely led to a drop in imports.




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 the ROW. This implies that there must have been large changes in relative prices between goods in China and the ROW which prevented international consumption risk-sharing.[5].

## 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[6]. Labor stands for the number of people employed divided by EAP.

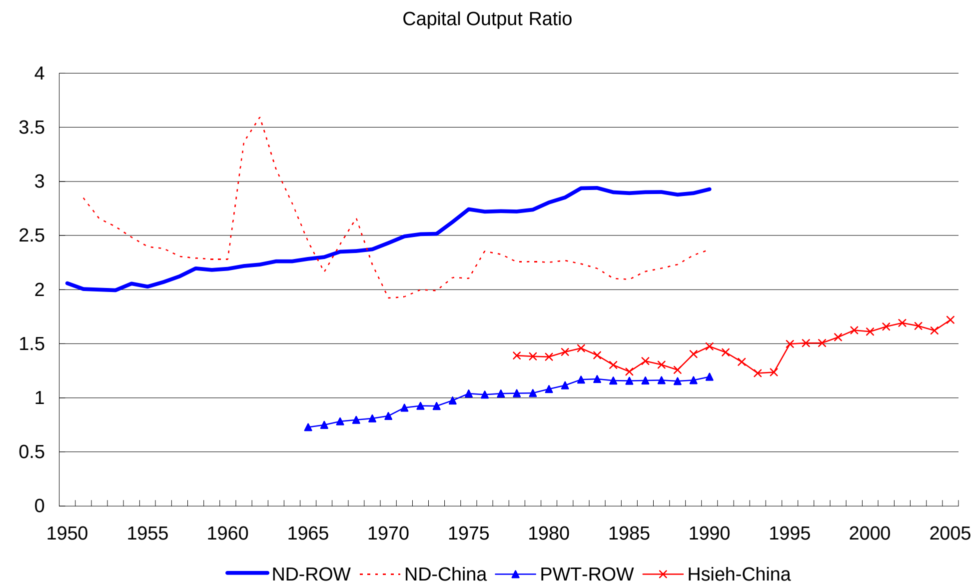
[5]In a two-country one-good model, the relative price is always one, which leads to strong correlation between consumption in both countries. For instance, if the periodical utility function is in the form of:

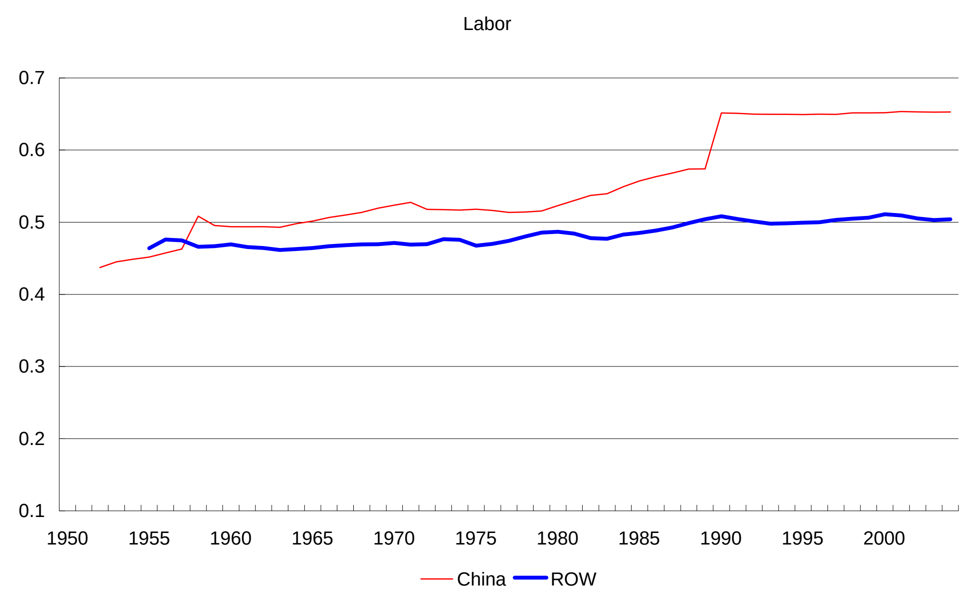
$$u = \Psi \log c_t + (1 - \Psi) \log(1 - l_t)$$

in both countries, there should be perfect correlation between consumption growth in both countries.

[6]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

Figure 5. Production Factors




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)) reported real capital stock in 1987 local prices. According to the ND (1993) 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[7]. According to PWT 5.6, 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) reported 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 (2003), the capital-output ratio in China is similar to that in the ROW. Although the level of the ratio depends on the currency unit and the base year used, both ND (1993) and Bai, Hsieh and Qian (2006) imply that there is no noticeable growing trend in the capital-output ratio. This means that the growth in China has not been driven by rapid capital accumulation[8].

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 input[9]. Employment per EAP in the ROW is roughly stable and slightly increases throughout the period. Employment per EAP in China jumps in 1990 due to a revision in the statistics.

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 respects. 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 (1993) and the perpetual inventory method assuming a 3.5

[7]PWT uses the Heston-Summers method for PPP adjustment. They have not yet updated the capital per worker series in version 6.2.

[8]Young (1995) showed that rapid growth in emerging East Asian economies during the 70s and 80s was driven mainly by rapid capital accumulation.

[9]For France, we use the LABORSTA database from the International Labor Organization.

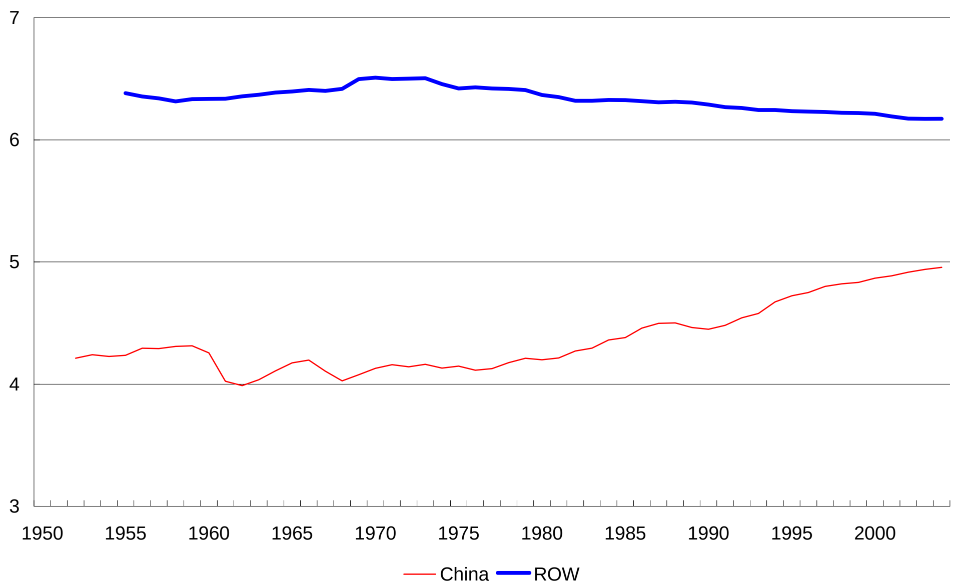
percent depreciation rate in both countries[10]. Second, as mentioned above, data on hours worked per worker is not available for China. Since we use the employment data as a proxy for total hours worked (labor), our measure of aggregate TFP includes changes in hours worked per worker. Even the employment data in China is not reliable since there is a data break which will cause a jump in aggregate TFP. 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[11]. The amazing coincidence in the opening-up and the take-off implies that there might be a common source of these two. In this paper, however, 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.

[10] This gives 3.2% for the ROW and 3.75% for China. For convenience, we choose 3.5% as the common depreciation rate.

[11] 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. We also show that a model that can successfully explain the impact of China’s opening-up and growth must be able to account for the lack of consumption risk-sharing while incorporating a shock which manifests itself as a gradual growth in aggregate total factor productivity. In the following section, we consider a dynamic stochastic general equilibrium model incorporating these 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)[12]. 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 goods market. The terms of trade are defined as the relative price of the two. Labor and capital are internationally immobile. Final goods in each country

[12] The competitive equilibrium setting follows Raffo (2006).

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.

## 3.1 Households

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:

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

subject to budget constraints:

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

That is, the households receive income from labor $l_{i,t}$, capital $k_{i,t}$, lump-sum transfer $T_{i,t}$[13] 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 $d_{i,t+1}$ where $w_{i,t}$ and $r_{i,t}$ are real wages and rental rates in domestic final goods units. The price of international claims $Q_t$ is common to both countries[14]. 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:

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

## 3.2 Intermediate Goods Firms

The representative intermediate goods firms in each country specialize in producing goods $a$ and $b$ respectively. The firms produce intermediate goods

[13] As mentioned below, there is lump-sum transfer only in China.

[14] The model is deterministic and the international claim is a redundant asset.

from labor and capital using a constant returns to scale technology:

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

where $z_{i,t}$ represents the production efficiency of the intermediate goods firm which we refer to as "productivity" in order to distinguish it from aggregate TFP. Intermediate goods firms maximize profits:

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

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

## 3.3 Final Goods Firms

The representative final goods firms in each country produce final goods from intermediate goods using Armington aggregation technologies:

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

where $\eta_{C,t}$ and $\eta_{R,t}$ are the weights of home goods.

As shown in the previous section, Chinese trade was roughly balanced especially prior to the reform. 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 goods firm is

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

where $\tau_{C,t}$ is the tariff rate. On the other hand, we assume that the ROW government does not impose tariffs on its imports from China[15]. Thus, the profit maximization problem for the ROW is

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

[15] In the appendix, we also provide for a model in which China also uses export subsidies to promote trade.

## 3.4 Government

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

$$\tau_{C,t} p^a_{C,t} b_{C,t} = T_t. \tag{6}$$

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:

$$a_{C,t} + \frac{1-\pi}{\pi} a_{ROW,t} = y_{C,t} \tag{7}$$

and

$$\frac{\pi}{1-\pi} b_{C,t} + b_{ROW,t} = y_{ROW,t} \tag{8}$$

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

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

The market clearing condition for claims[16]

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

implies

$$\pi(p^a_{C,t} y_{C,t} - G_{C,t}) + (1-\pi) rer_t (p^b_{R,t} y_{R,t} - G_{R,t}) = 0.$$

## 3.6 Prices

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

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

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

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

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

$$rer_t = \frac{P_{R,t}}{P_{C,t}} = \frac{p^a_{C,t}}{p^a_{R,t}} = \frac{p^b_{C,t}}{p^b_{R,t}} = \frac{u_{cR,t}}{u_{cC,t}}.$$

Also, by definition,

$$tot_t = \frac{p^a_{C,t}}{p^b_{C,t}} = \frac{p^a_{R,t}}{p^b_{R,t}}.$$

## 3.7 Exogenous Variables

### 3.7.1 Home Goods Weight

The home goods weight defines the shape of the final goods production possibility frontier, and thus determines the long-run share of home goods within the Armington aggregator to produce final goods. We interpret the opening-up and reform policy as a sudden reduction in Chinese home goods weight $\eta_{C,t}$. Since a reduction in home goods weight increases the demand for imports and stimulates exports by reducing the demand for home goods, this can explain the sudden increase in openness:

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

in 1978.[17]

### 3.7.2 Productivity

Sources of TFP growth in China are discussed in studies such as Dekle and Vandenbroucke (2006) and Young (2003). Unlike these studies, the main purpose of our paper is not to reveal the source of TFP growth, but to deduce its impact on China and the ROW along with home goods weight shocks.

One accounting issue 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 the GDP accounting sense, the value of production

[17] 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.

in country $i$ is $p^j_{i,t} y_{i,t}$. Thus, aggregate TFP in each country is $p^j_{i,t} z_{i,t}$, which means that changes in both $p^j_{i,t}$ and $z^j_{i,t}$ affect aggregate TFP. In the model, we treat $z^j_{i,t}$ as exogenous and $p^j_{i,t}$ as endogenous.

### 3.7.3 Import Tariffs

In the previous section, we showed 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) reported tariff data over the 1982-2001 period whereas we are interested in the period before 1978. Lardy (2002) also stated that tariffs did not have important effects on imports since the government directly determined the quantities of imports.

In this paper, we compute the 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. One criticism of our model could be that we do not incorporate financial market disturbances such as limits on financial transactions and exchange rate control. However, we believe that a model with incomplete financial markets will produce similar results to ours since our as-if tariffs include these distortions in the financial market[18].

## 3.8 Competitive Equilibrium

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

[18] A one-to-one mapping is not possible since financial market imperfections will create a wedge between the growth rate of marginal utility of consumption across countries, while tariffs create a wedge between the level of marginal utilities across countries.

# 4 Quantitative Analysis

## 4.1 Parameter Values

We assume the EAP weight to be constant at $\pi = 1/2$[19]. The original literature solves the 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 show 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 of 2.5 and the steady state labor level of 0.3[20].

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 goods weight $\eta$ 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 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 goods weight $\eta$. We assume a steady state import share of 0.15 following Backus, Kydland and Kehoe (1994), which implies steady state openness equal to 0.3.

Table 1 presents the parameter values common to both countries.

[19] In the data, this ranges from 0.58 to 0.64. For simplicity, we assume 0.5. Raffo (2006) showed that the country size does not affect the equilibrium allocation for a given export share.

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

Table 1. Parameter Values

| | |
|---|---|
| $\pi$ | 0.5 |
| $\varepsilon$ | 1.5 |
| $\delta$ | 0.035 |
| $\beta$ | 0.95 |
| $\Psi$ | 0.34 |
| $\eta$ | 0.76 |
| $\theta$ | 1/3 |

## 4.2 Simulation

In this section, we describe how we obtain nonlinear equilibrium paths of endogenous variables given exogenous changes in home goods weight and productivity over the 1950-2100 period. Since both home goods weight and productivity are not directly observable, we choose them such that the endogenous Chinese GDP and openness roughly match the data. Specifically, we assume that the openness and detrended GDP growth rate were 10% and 0% prior to 1978 and 30% and 5% after 1978. We set the post-1978 openness constant at 30%, which is the value implied by the symmetric steady state in section 3[21]. In addition, we impose a balanced trade constraint throughout the whole period.

Since the model is deterministic, the paths of exogenous variables are perfectly foreseen. It does not seem reasonable to assume that the Chinese agents knew that the opening-up and reform policy would occur in 1978 beforehand. Thus, we divide the period into two. The first period is illustrated by low openness and GDP in China. The second period starts in 1978 in which suddenly openness and GDP growth rate increased. This setting implies that the agents were suddenly surprised by the new path of exogenous variables and reoptimized in 1978[22].

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 goods weight, $\eta_C = 0.76$, produces openness roughly equal to 10%[23]. Next,

[21] This is lower than the observed level in chapter 2, however, the openness in chapter 2 includes trade with countries other than the G7 countries.

[22] This is the same setting as the sudden surprise exercise in Meza and Quintin (2007) and Kehoe and Ruhl (2007).

[23] It is well known that smaller countries have higher trade shares. Thus, this initial

in 1978, we introduce a drop in home goods weight so that openness suddenly increases. Finally, we set paths for productivity growth and home goods weight over the 1978-2100 period such that China's openness remains around the 30% level and detrended GDP grows roughly at the 5% level. We extrapolate from 2004 assuming that China's output continues to grow by 5% until it converges to the ROW level[24]. This procedure is closely related to the business cycle accounting method introduced by Chari, Kehoe and McGrattan (2007). They elicit exogenous wedges from equilibrium linearized decision rules and data within a stochastic framework while we elicit exogenous variables from data and a deterministic system of equations, which is the method they used in an earlier version of their paper.

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

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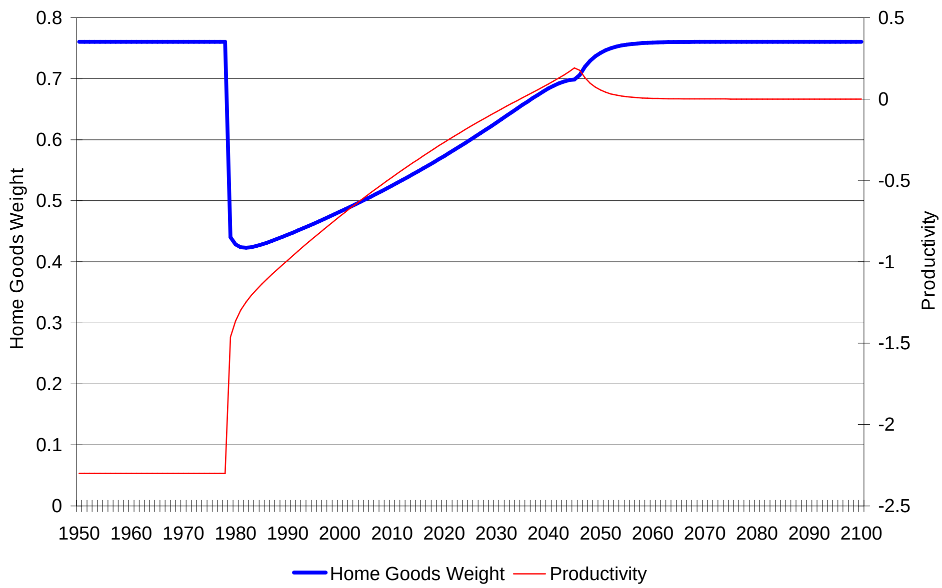
home bias level should be considered high given China's degree of development prior to the opening.

[24] Changing the speed of convergence does not affect the result. We can alternatively use a smoother path of convergence for the 2004-2100 period.

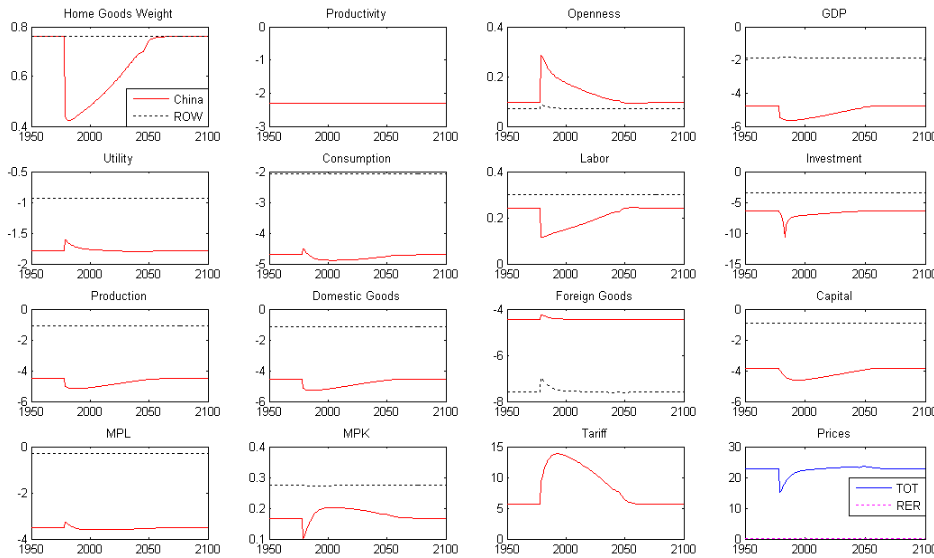
Figure 7. Exogenous Variables




### 4.2.1 Simulation with Home Goods Weight Shocks

Figure 8 presents the results of simulating the model with home goods weight shocks keeping productivity constant at its initial level while maintaining the balanced trade constraint. All growing variables are expressed as log deviations from their long-run steady states while home goods weight, openness and labor are expressed as levels.

Figure 8. Simulation Results with Home Goods Weight Shocks



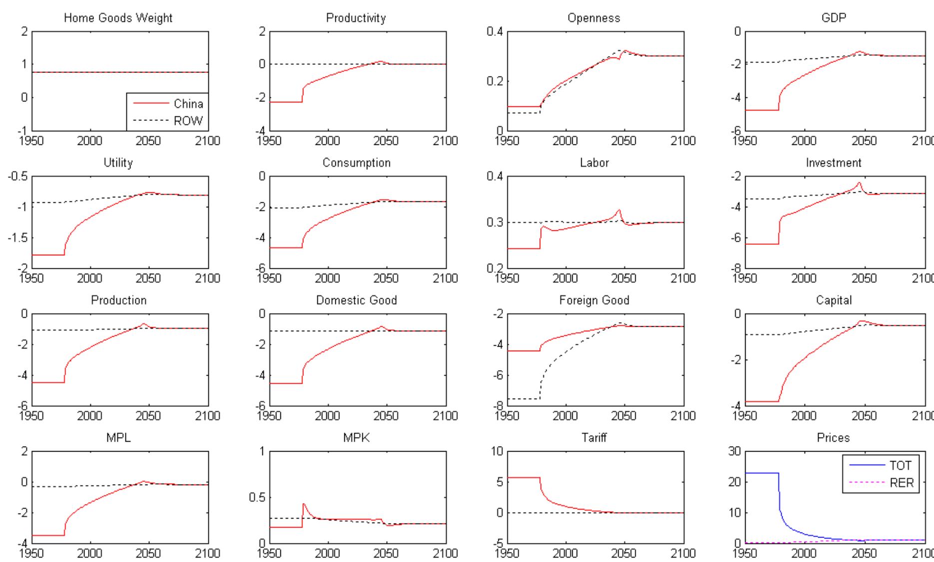

The sudden reduction in China's home goods weight causes a fall in the world relative demand for good $a$. Since the demand for home goods falls, China will produce less. Thus, in China both labor and investment fall and capital stock falls following the drop in investment. Consumption initially increases since the trade account remains balanced while investment falls more than output does. Consumption gradually falls following the decline in capital stock. As the home goods weight returns to the steady state, both labor and capital stock return to the steady state. As a result, China's utility is higher in the short run and becomes slightly lower in the medium run relative to the initial level. As the home goods weight returns to the initial level, the economy goes back to the initial level. Tariffs are high throughout the period since productivity remains low. Since Chinese agents are better off running a trade deficit while their income is below the steady state, the government has to impose high tariffs to prevent it.

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. Nonetheless, the effect of this shock is small in the ROW since the country size of China relative to the ROW is very small.

### 4.2.2 Simulation with Productivity Shocks

Figure 9 shows the results of simulating the model with only productivity shocks keeping the home goods weight constant at its initial level while maintaining the balanced trade constraint.

Figure 9. Simulation Results with Productivity Shocks



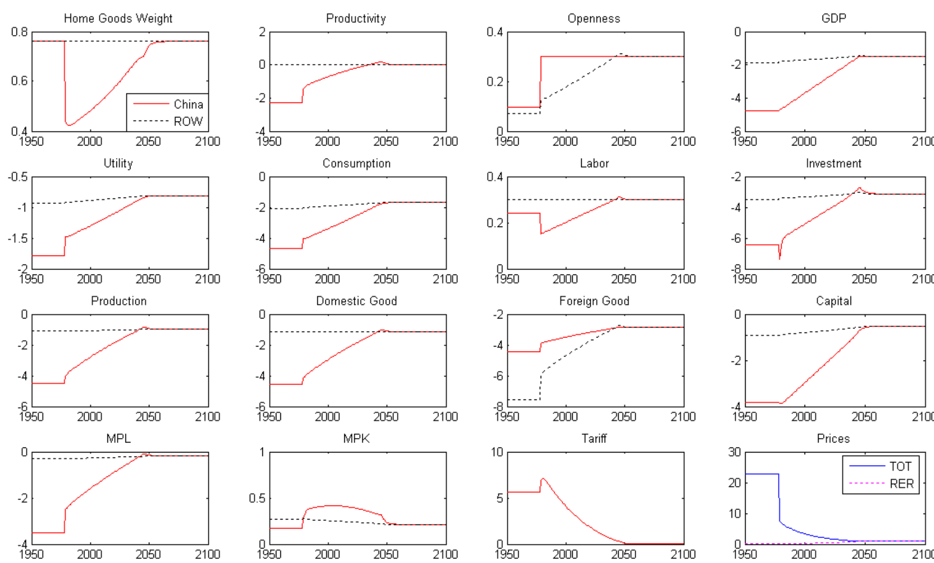

As in a standard neoclassical optimal growth model, a long-run increase in productivity causes China's output, investment and consumption to increase. China's labor grows and ends up at the steady state level since the price distortion vanishes in the long run as productivity approaches the steady state level. China's utility constantly grows as productivity increases, which implies that the effect of the increase in consumption outweighs the effect of the increase in labor on welfare.

Though China's productivity growth does not have spill-over effects on ROW productivity, the ROW is affected through the terms of trade effect. As China's productivity increases, the relative price of good $a$ falls, which is a positive terms of trade shock from the ROW perspective since the ROW's products are more valuable and foreign products are more affordable. The ROW produces more and consumes more so consumption and labor both increase. The effect is significant since as productivity grows the size of China also grows, which leads to a significant increase in trade and thus the benefits from it.

### 4.2.3 Simulation with Home Goods Weight and Productivity Shocks

Figure 10 shows the results of simulating the model with both shocks while maintaining the balanced trade constraint. The results can be considered as a combination of the two previous results[25].

Figure 10. Simulation Results with Both Shocks




Regarding the discrepancy of the model prediction and the data, some variables such as investment, labor and consumption in China directly inherit the jumps in home goods weight and productivity shocks in 1978. Investment

[25] The results are not simple sums of the previous two counter-factual exercises since the model is solved with a non-linear method and the previous simulations assumed balanced trade in each case, which implies different tariffs for each simulation.

and labor adjustment costs and habit formation in consumption might be a sensible way to account for this discrepancy. Also, the model predicts a 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 China's productivity growth[26]. We do not adjust for these issues in order to make our model as simple as possible.

#### 4.2.4 Welfare Analysis

In order to further assess the effect of each shock on consumers' welfare, we compute the welfare improvement in each country given the shocks in Table 2. Welfare improvement is defined as the present value of the difference between the periodical utility and the initial utility level summed over the 1978-2100 period. The column titles $\eta_C$, $z_C$, $\eta_C \& z_C$ stand for simulations with only home goods weight shocks, with only productivity shocks and with both shocks.

Table 2. Welfare Analysis

| | $\eta_C$ | $z_C$ | $\eta_C \& z_C$ |
|---|---|---|---|
| China | 0.95 | 9.52 | 8.31 |
| ROW | 0.03 | 0.84 | 0.82 |

It turns out that China is better off with only home goods weight shocks, which implies that the short-run effect of labor decline dominates the medium-run effect of consumption decline. On the other hand, the impact of China's home goods weight shocks on the ROW is very small. Both China and the ROW are better off due to the growth in Chinese productivity. The overall effect is that both China and the ROW are better off due to the opening-up and growth of China.

### 4.3 Simulation without the Trade Balance Constraint

In this section we consider a case in which the Chinese government does not impose a balanced trade constraint after the opening-up. In other words, we remove tariffs instantaneously in 1978 while allowing the trade balance

[26]Indeed, the crude TFP measure is decreasing in the ROW. This suggests that productivity in the ROW may have been falling recently.

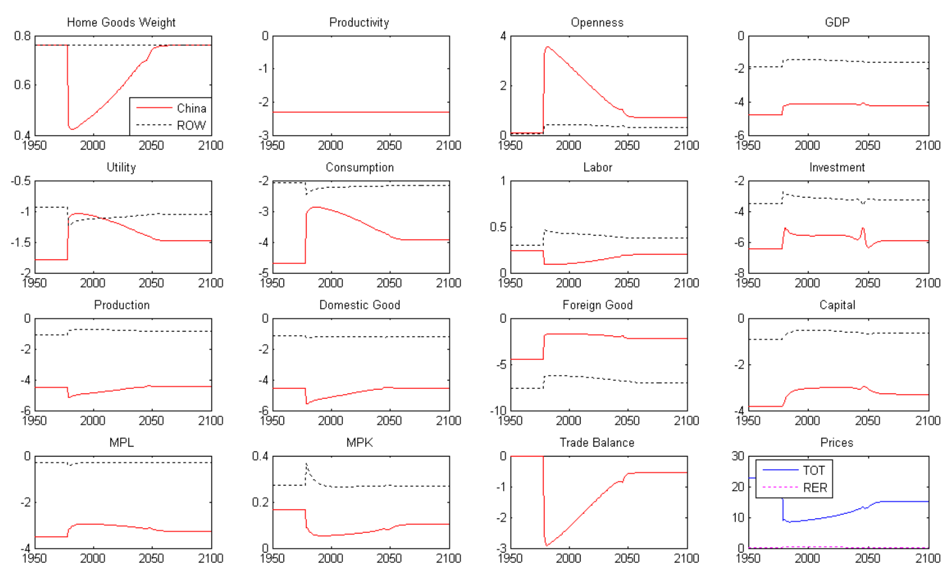
to fluctuate afterwards. For this counter-factual exercise, we use the same initial states and the same shock levels assuming that trade was balanced until 1977.

Common to all cases, removal of the trade balance constraint in 1978 has a significant effect on welfare. In China, removal of the tariffs leads them to import more goods produced in the ROW and use less of their own products. As a result, they work less and consume more, which makes them better off. On the other hand, since the world demand for good $b$ suddenly increases, labor and investment increase in the ROW. Since the resources are used in investment, the ROW can consume less in the short run. Therefore the ROW is actually worse off due to the removal of trade barriers. The following simulation results can be considered as combinations of the original results and the above-mentioned effects of removing the balanced trade constraint.

#### 4.3.1 Simulation with Home Goods Weight Shocks

Figure 11 shows the simulation results with home goods weight shocks keeping productivity constant at the initial level.

Figure 11. Simulation Results with Home Goods Weight Shocks ($\tau = 0$)

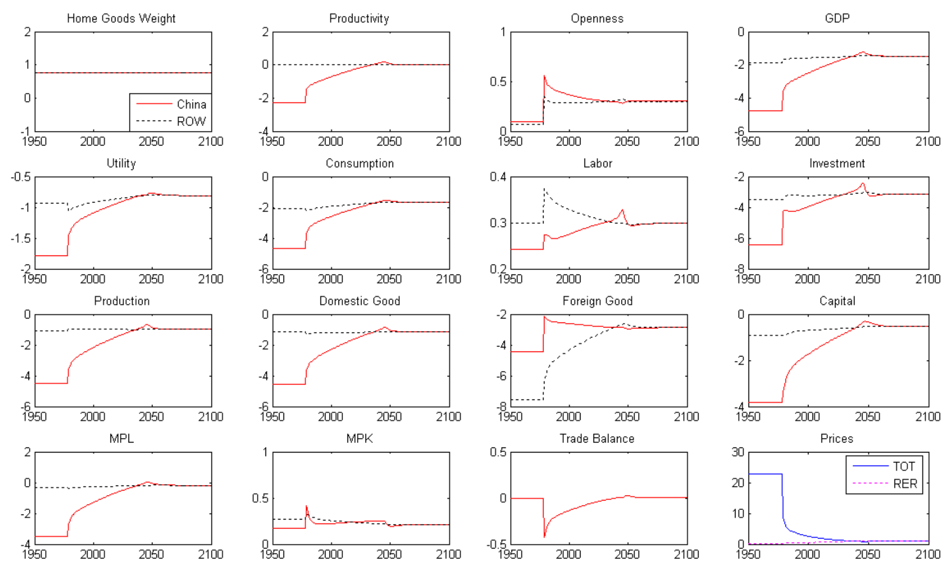


The results show that China would have been better off while the ROW would have been worse off as a result of China's home goods weight decline under free trade. As in the benchmark case, Chinese agents work less due to the drop in home goods demand. In addition, since China borrows from abroad running a trade deficit, they can consume more. Thus, China is even more better off than in the benchmark case. On the other hand, the ROW works more since the demand for good $b$ increases. Also, since they lend to China, they consume less. Hence, the ROW is worse off.

### 4.3.2 Simulation with Productivity Shocks

Figure 12 shows the simulation results with productivity shocks keeping the home goods weight constant at the initial level.

Figure 12. Simulation Results with Productivity Shocks ($\tau = 0$)

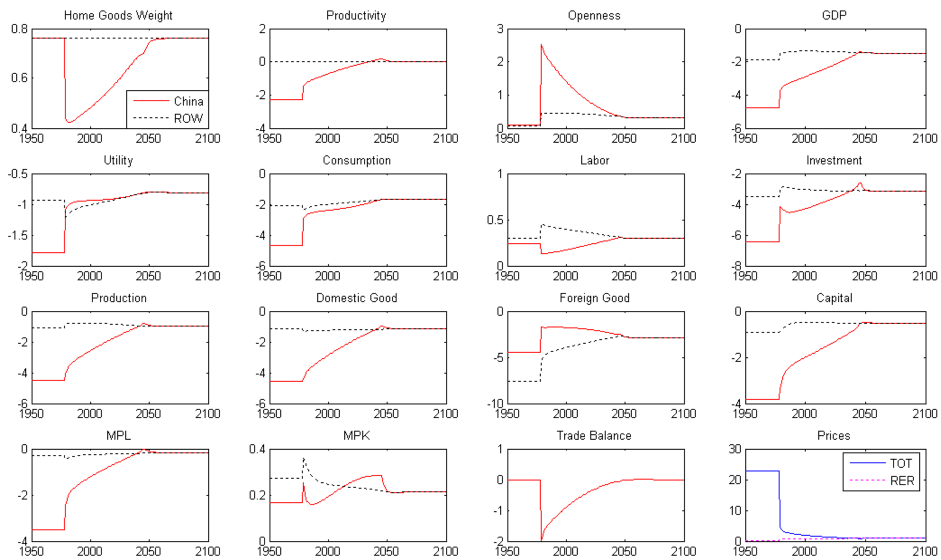



The results show that China is better off for sure as a result of productivity growth. Once the balanced trade constraint is relaxed, China borrows from the ROW running a trade deficit and increases consumption. At the same time, the Chinese work more due to the increase in productivity. It turns out that the periodical utility increases for all periods. On the other hand, the sudden drop of tariffs makes the ROW worse off temporarily. In the long run, the steady state consumption in the ROW is higher than that in the initial state. Thus, the effect on ROW welfare is ambiguous.

#### 4.3.3 Simulation with Home Goods Weight and Productivity Shocks

Figure 13 shows the results of the simulation with both shocks.

Figure 13. Simulation Results with Both Shocks ($\tau = 0$)




From the previous two results, we know that China is unambiguously better off. On the other hand, in the ROW periodical utility initially falls due to the removal of trade restrictions and the decline in Chinese home goods weight, and then grows due to the terms of trade effect from the Chinese productivity growth so the total effect of the shocks is ambiguous. In order to quantify the effects, we conduct a welfare analysis as in the benchmark case.

#### 4.3.4 Welfare Analysis

Table 3 shows the results of the welfare analysis.

Table 3. Welfare Analysis

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

The results indicate that while China is better off, the ROW is worse off after home goods weight and productivity shocks. 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 overall it is worse off. In addition, the total world welfare is higher than in the case when there is the balanced trade constraint. This counter-factual exercise shows that the Chinese balanced trade policy was actually welfare improving from the ROW's point of view and welfare deteriorating from China's.

The result that the balanced trade policy makes the ROW better off is interesting since today the ROW seems more supportive of Chinese free trade than China is. Also, from China's point of view, it is puzzling why they did not engage in free trade by which they would have been better off. One possible explanation is that China protected its domestic industry from international competition to buy some time to adopt foreign technology. This kind of infant industry protection policy may be key to explain also the TFP growth.

# 5 Conclusion

In this paper, we assessed the global impact of China's opening-up and growth within a standard neoclassical two-country two-good framework. We showed that a sudden drop in home goods weight and gradual productivity growth in China can account for the sudden increase in openness and rapid output growth in China. We found that the home goods weight shock per se is welfare improving for China while its impact on the ROW is small. We also found that productivity shocks are welfare improving for both China and the ROW. Thus, we conclude that China's reform and opening-up policy was welfare improving for both economies if it led to significant productivity growth. We also showed that the China's balanced trade policy helped the ROW rather than China.

Since we focused on the impact of shocks on China and the ROW, we did not model the source of productivity growth and took 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. In any case, we consider our model as a foundation to understand the impact of Chinese growth.

Our conclusion that China's balanced trade policy was helping the ROW is somewhat controversial considering the political debate on Chinese free trade. China's exchange rate policy has been accused mainly by the US since the undervalued RMB allegedly widened its trade deficit with China and thus caused job losses in manufacturing. However, in our model, devaluing the RMB is like removing tariffs from the Chinese point of view, which would make the ROW worse off since more working brings more disutility. In order to incorporate the cost of job losses, we can add job search structure or simply introduce heterogeneity in worker and non-worker preferences.

Finally, stochastic simulations may have different quantitative implications from our results. In our deterministic settings, Chinese agents correctly predict the steady state and the rapid growth path after 1978, which gives a large incentive for Chinese agents to run a trade deficit. In a stochastic setting, this income effect may not be so large. However, we believe that the qualitative results should not differ.

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# A Export Subsidy Model

Instead of home goods weight shocks, we can model shocks to China's subsidies on its exports as the driving force of sudden changes in trade volume. The modification is straightforward such that now besides levying tariff on imports, the Chinese government gives subsidies $s_{C,t}$ to foreign exports. Hence, the final goods firms' problem in the ROW is

$$\max G_{ROW,t}(a_{ROW,t}, b_{ROW,t}) - (1 - s_{C,t})p^a_{ROW,t}a_{ROW,t} - p^b_{ROW,t}b_{ROW,t}.$$

Also, the government budget constraint changes accordingly to

$$\tau_{C,t}p^a_{C,t}b_{C,t} + s_{C,t}p^a_{ROW,t}a_{ROW,t} = T_t.$$

China's subsidies and tariffs are at levels such that trade is virtually balanced and openness is at the pre-opening level. Once China opens up to the international market, tariffs dramatically decline, which increases the trade volume, and subsidies adjust accordingly such that trade remains balanced. Qualitatively speaking, this model can generate similar results to those from the model with home goods weight shocks. However, quantitatively speaking, we found it difficult to replicate patterns of openness and the trade balance with export subsidies and tariffs.