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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. The opening-up of China is beneficial to the ROW if it led to significant productivity growth in China. Furthermore, China's balanced trade policy after the opening-up has helped the ROW rather than China. Hence, according to a simple neoclassical model with complete markets, a gradual trade liberalization in China is preferable to a drastic one from the ROW perspective.

Keywords: Chinese Growth; Reform and Opening-up; Productivity; Terms of Trade
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 its "openness", i.e. the trade volume to GDP ratio. On the other hand, the rest of the world (ROW), which we define as the aggregate of the G7 countries, grew relatively constantly over the 1950-2004 period. Shouldn't the ROW be affected by the sudden entry and opening-up of China? If so, what are their effects on welfare? 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. Furthermore, China's balanced trade policy after the opening-up has helped the ROW rather than China.

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 dramatically increased from roughly 0.1 to above 0.4. Second, the annual growth rate of the PPP adjusted per capita real GDP was around 2.8 percent between 1952 to 1978 then jumped up to 7.6 percent on average over the 1978-2004 period. Finally, trade was roughly in balance throughout the pre-1978 period. In this paper, we identify shocks that replicate these facts in the Chinese economy and deduce their impacts on the ROW within a standard neoclassical two-country two-good model.

Several studies have assessed the source of total factor productivity (TFP) growth in China. 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. Young (2003) claims that the growth rate of the non-agricultural TFP is "respectable but not outstanding" after adjusting for the inflation understatement, the rising labor force participation and the accumulation of human capital. Islam, Dai and Sakamoto (2006) compute TFP growth with the "dual approach" introduced by Hsieh (2002) and found that the post-reform Chinese TFP growth was high but has recently decelerated¹. Fu and Gong (2008) find that the post-reform TFP growth is mainly due to the R&D activities of the indigenous firms rather than those of the foreign firms operating in China. In this paper, we do not discuss the source of China's productivity growth but focus on the impact it has on both the domestic and the ROW economies.

There are also studies on the impact of China's entrance into the world trade market. For instance, Coleman (2007) shows using a static model that the entrance of China caused

¹They report post-reform TFP growth rates of 5.73 percent for the 1978-1984 period, 1.20 percent for the 1984-1991 period, and 2.98 percent for the 1991-2002 period respectively.

an international production adjustment among neighbor countries through its effect on international relative prices. McKibbin and Woo (2003) simulate a global macroeconomic model and shows that the accession of China to WTO will improve the welfare in China; have little effect on OECD countries; and deteriorate the welfare in ASEAN countries. Our motivation is similar to McKibbin and Woo (2003) while we focus on the Reform and Opening-up policy rather than the accession to WTO. In this paper, we assess the dynamic effect of the drastic opening-up and rapid growth of China on the ROW within a dynamic general equilibrium setting².

In order to assess the impact of shocks in China on the ROW, we construct a two-country two-good model à la Backus, Kehoe and Kydland (BKK 1994). Each economy produces specialized intermediate goods that are aggregated in both economies in order to produce final goods. In this model, we can define the terms of trade as the price of Chinese goods relative to the ROW goods. The terms of trade plays an important role in transmitting shocks across economies and providing a cushion for consumption risk-sharing³.

We assume two key shocks to the Chinese economy; shocks to the weight on domestically produced intermediate good used for final good production (home goods weight) and shocks to the production technology of the intermediate good firm (productivity). The shocks to the home goods weight are shocks to the final good production function. They also affect aggregate productivity through their impact on the relative price between home and foreign intermediate goods. We attribute the Reform and Opening-up policy to a sudden exogenous fall in this weight, which leads to an increase in openness as the importance of foreign good rises while that of home goods falls. In our model, aggregate TFP consists of the productivity in the intermediate good firm and the price of the home good relative to the domestic final good price level. Productivity in the intermediate good sector is the main driving force of the TFP and output growth.

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 goods trade and the imports of targeted goods were financed by exports of products redundant in the domestic market. Therefore, China was in financial autarky in the sense of Cole and Obstfeld (1991); the country was open for trade but not for foreign capital. In the model, for convenience, we assume that the Chinese government imposed tariffs on imports in order

²The global macroeconomic model in McKibbin and Woo (2003) is dynamic but assumes rule-of-thumb behavior of agents. Therefore, it is not a dynamic general equilibrium model.

³In a one-good two-country model such as Baxter and Crucini (1995) the cross-country consumption correlation is extremely high. The consumption correlation is not high in China and the ROW.

to maintain balanced trade and thus financial autarky. 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 while attracting foreign direct investment during the 1990s. However, our simulation results suggests that there must have been a strong force that prevented China to run a trade deficit and massive capital inflows.

Since we do not directly observe the data of the home goods weight, intermediate goods firm productivity and tariffs, we deduce them by matching China's openness, output and trade balance in the model to the data. This procedure is closely related to the business cycle accounting method introduced by Chari, Kehoe and McGrattan (2007). They elicit exogenous wedges from equilibrium decision rules and data within a stochastic framework while we compute exogenous variables from data and a deterministic system of equations. We simulate the model given the computed values of the home goods weight, productivity and tariffs assuming that the agents were suddenly surprised by the new path of exogenous variables and re-optimized in 1978. This approach follows the 'sudden surprise' simulations in Meza and Quintin (2007) and Kehoe and Ruhl (2009).

We find that opening-up *per se* is welfare improving for China while it has little impact on the ROW since China is small relative to the ROW in the initial state; China's productivity growth is welfare improving not only for China but also for the ROW due to the terms of trade effect; and the balanced trade constraint improved the welfare in the ROW while deteriorating that in China. The result that the Chinese balanced trade constraint helped the ROW rather than China is not a puzzle. Without the balanced trade constraint, the ROW would have to run a trade surplus in order to lend to China whose productivity and income is initially far below the steady state. Consequently, although its GDP increases, the ROW is worse off under free trade due to the drop in consumption and leisure. As a result, a gradual decline in Chinese tariffs as output grows is preferable to a drastic removal of them for the ROW.

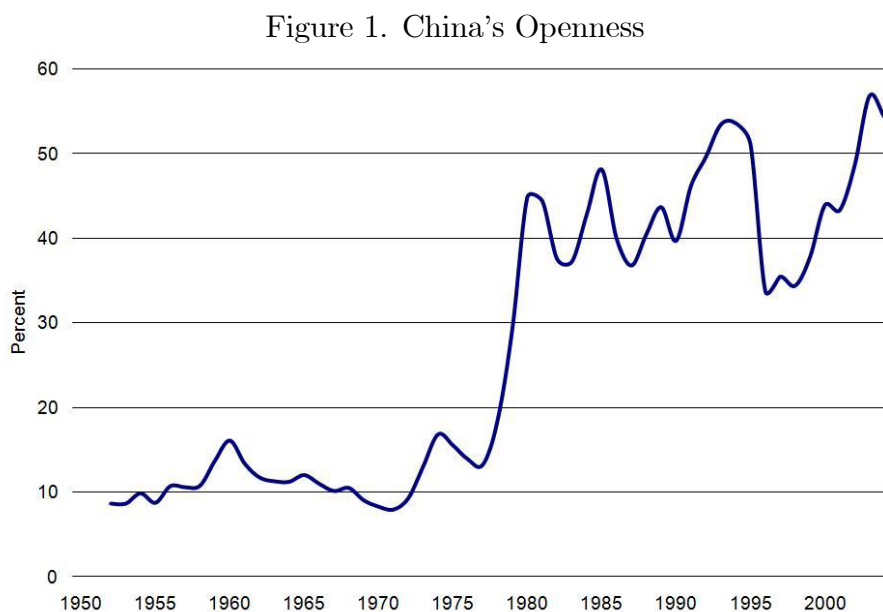
The remainder of the paper is organized as follows. In section 2, we document the data on China focusing on the opening of trade and the growth in GDP components. In section 3, we describe the model. In section 4, we present the quantitative results. Section 5 concludes the paper.

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 (PWT) 6.2 and is stated otherwise.

2.1 Openness

Figure 1 presents the “openness” of China defined as Trade Volume/GDP in real terms⁴. The sudden increase in trade in 1978 corresponds to the beginning of the “*Gaige Kaifang* (Reform and Opening-up)” policy. The entry of China to the World Trade Organization in 2001 surely increased the trade volume. However, historically speaking, 1978 had a much greater impact on openness. Therefore, we focus on 1978 as the turning point of the Chinese economy.



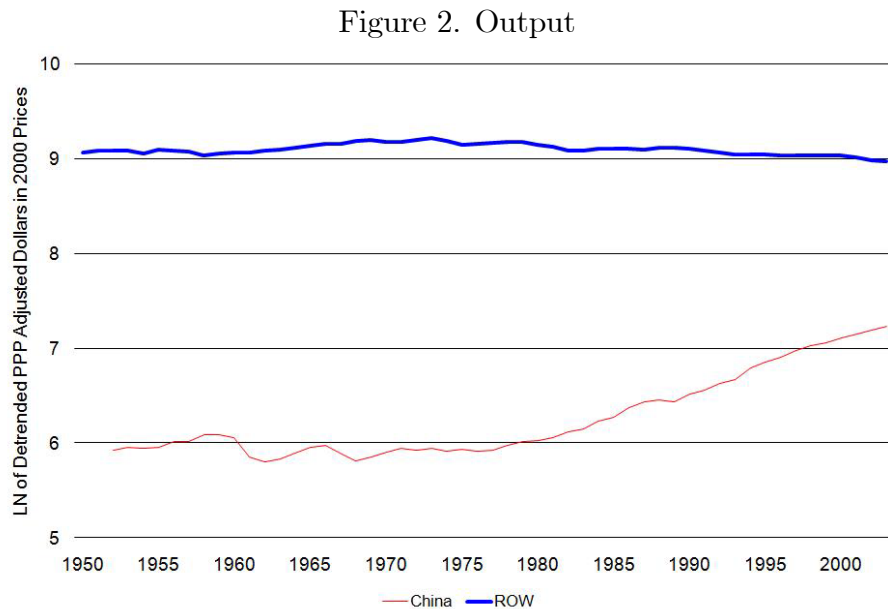
As described in Shirk (1994), the main aim of trade policy prior to 1978 was import-substitution. The government especially protected the steel and machinery industries from foreign competition by controls on imports, investment, capital flows and exchange rates. Trade was limited to the central foreign 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

⁴Note that this measure includes trade with non-G7 countries as well.

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 and investment goods increased dramatically.

2.2 Growth

Figure 2 presents PPP adjusted real GDP per equivalent adult (EQA) in China and the ROW⁵. The series are in log terms and linearly detrended by 2.6 percent per year which is the average annual per EQA growth rate of the ROW and the pre-reform China.



This figure shows that China’s output was far below that of the ROW and was growing roughly at the same rate as the ROW prior to the opening-up. Once the economy opened up, China’s output growth took off; the average annual output per EQA growth rate jumped up after 1978 to 7.6 percent from 2.8 percent during the 1952-1978 period. The growth rate of the ROW over the entire period is 2.5 percent.

Unlike the data on trade, output data relies on the Chinese official domestic statistics. Lardy (2003) shows that the World Bank, OECD and China National Economic Research Center all independently estimated the annual growth rates and found that the official data

⁵This series correspond to the series ‘rgdpeqa’ in PWT 6.2 where PWT defines “equivalent adult” as the the population above 15 years old plus half of the population below 15 years old.

after 1978 are overstated by more than 1 percent⁶. Wu (2007) claims that the reliability of Chinese statistics are questionable even after a revision based on the first national economic census in 2004. Our main results are not affected by moderate measurement errors.

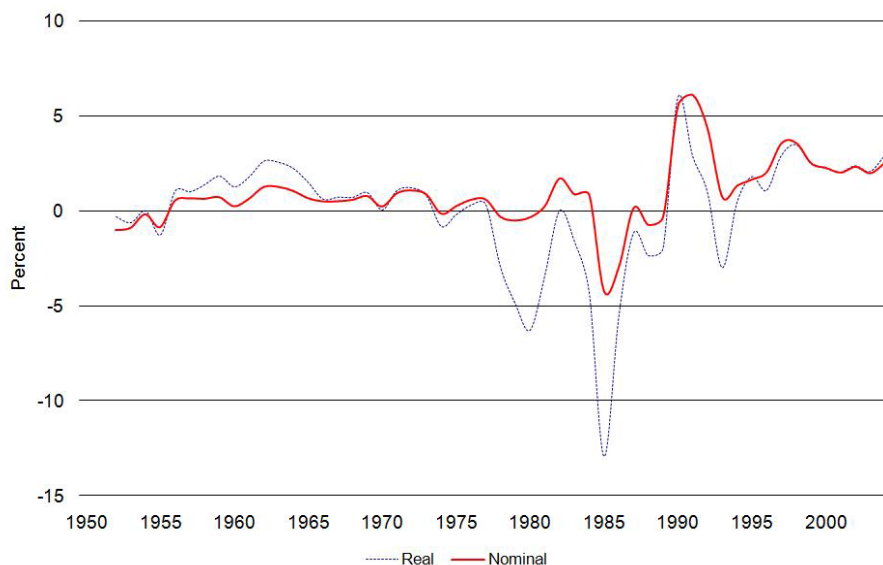
2.3 Trade Balance

Figure 3 presents China's real trade balance to GDP ratio. For comparison, we also provide the nominal measure which is not sensitive to the choice of 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 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 (2009), is to denominate exports and imports by their PPP adjusted weighted price indexes. 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 channel⁷.

⁶The estimated annual overstatement by the World bank for the 1978-95 period was 1.2%; that by OECD for the 1986-95 period was 3.8%; and that by the China National Economic Research Center for the 1978-98 period was 1.3%.

⁷Thus, 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 (2009).

Figure 3. China's Trade Balance



Prior to 1978, trade was directly controlled by the central government. Since the Chinese government financed the import of targeted goods through the exports of redundant goods, the trade was roughly balanced. After the Reform and Opening-up, there are some large fluctuations in the trade balance in 1985 and 1990. 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 and a large trade deficit. In 1987, the government introduced an import substitution policy that immediately eliminated the trade deficit. This leads us to believe that trade was controlled by the government even after the opening-up. The huge trade surplus in 1990 reflects the mild recession in 1988-89 which most likely led to a drop in imports. After 1994, the real trade balance turned positive and remained in surplus ever since in contrast with the growing U.S. trade deficit, which is also known as the global imbalance⁸.

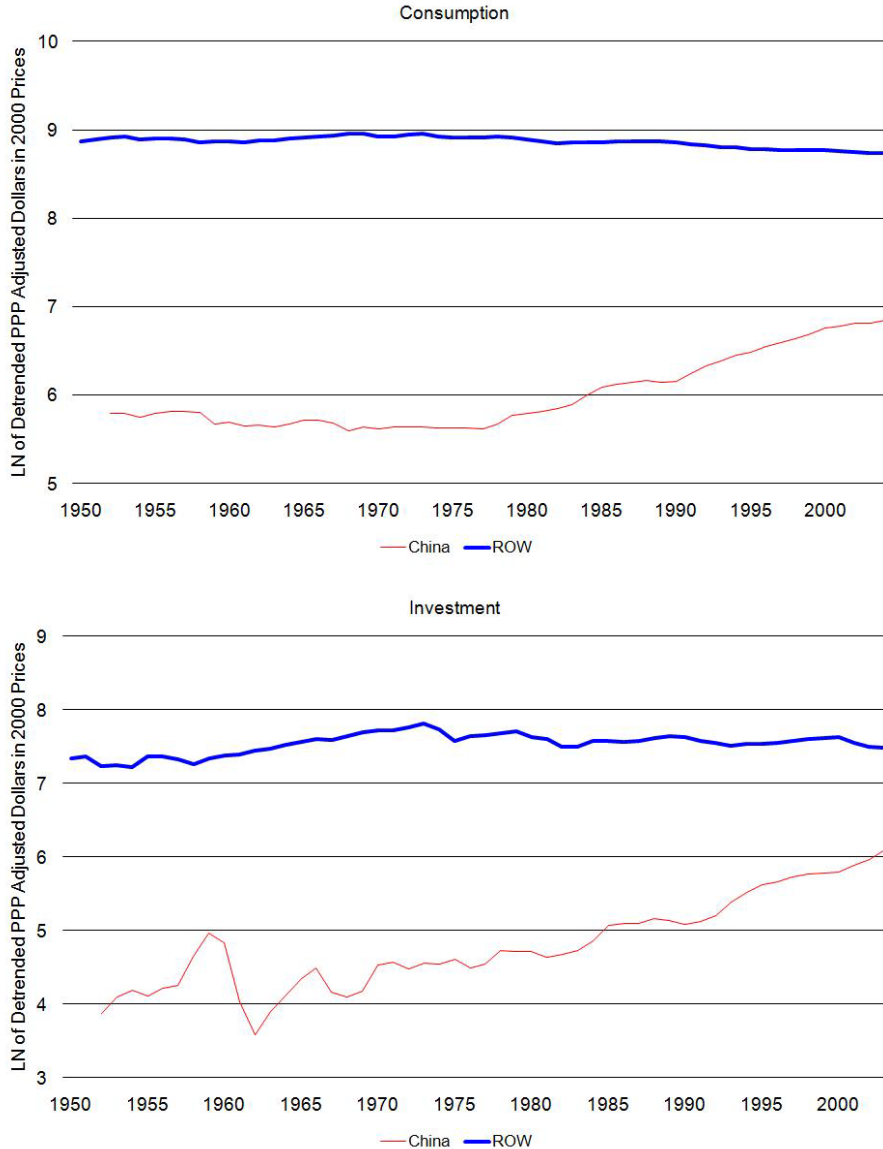
We do not investigate these individual episodes as explaining the fluctuation of the trade balance is beyond the scope of this paper. Instead, we argue that there must have been some pressure that forced trade to be nearly balanced throughout the entire period. We show later in the quantitative analysis section that otherwise there would have been a large trade deficit in China.

⁸One common interpretation on this issue is that China is manipulating the exchange rate in order to gain a large trade surplus. Woo (2008) explains that the large external surplus exists “because its dysfunctional financial system cannot intermedate the growing savings into investments”.

2.4 The Demand Side

Figure 4 presents the GDP components, consumption and investment. Consumption per EQA includes private and government final consumption expenditure. Investment per EQA includes private and government fixed investment. Both of these series are linearly detrended with the same rate as GDP per EQA, 2.6 percent.

Figure 4. GDP Components

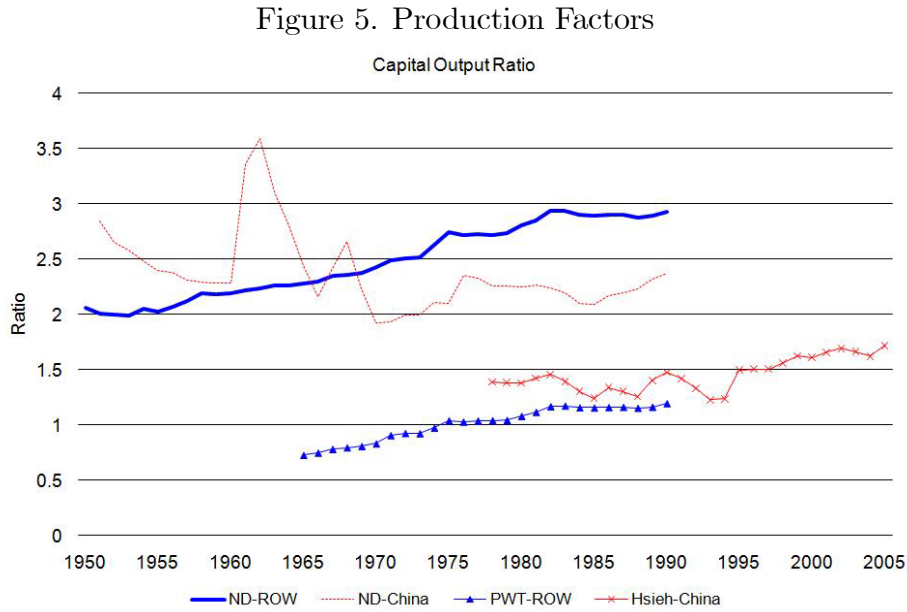


Clearly, Chinese consumption took off in 1978 as GDP did whereas the trend-break in investment is somewhat less obvious. The interesting point is that there is no correlation

between consumption in China and the ROW⁹. This implies that there must have been large changes in relative prices of goods or limitations in international transactions between China and the ROW which prevented international consumption risk-sharing.

2.5 The Supply Side

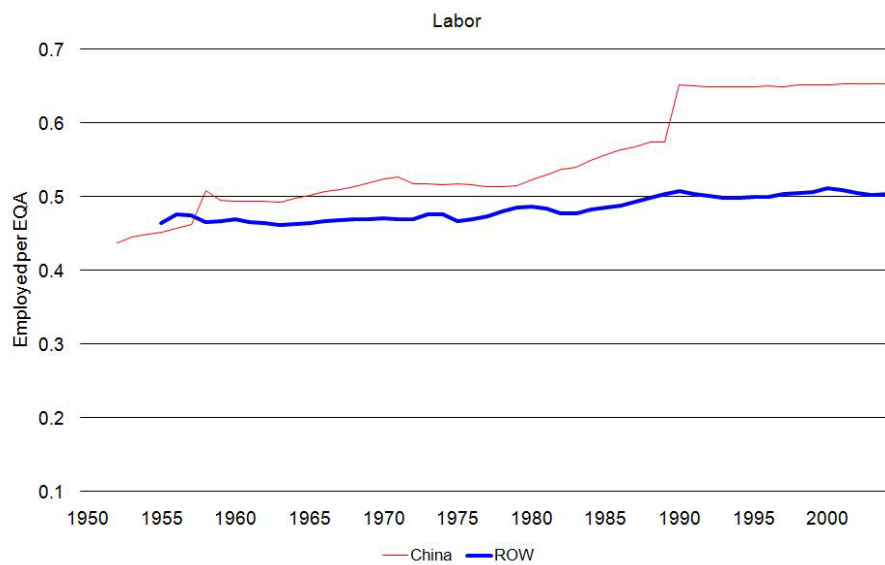
Figure 5 provides data of the capital stock to output ratio and labor, which stands for the number of people employed divided by EQA.



⁹In 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.



We compute the capital stock to output ratio from several sources¹⁰. Nehru and Dhareshwar (ND (1993)) constructs real capital stock series 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 Penn World Table (PWT) 5.6 which reports capital stock per worker in PPP adjusted 1985 international dollars¹¹. 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) reports nominal capital-output ratio in China over the 1978-2005 period. Adjusting for relative prices, the average real capital-output ratio in 1978 yuans is 1.45. According to ND (1993), the capital-output ratio in China is similar to that in the ROW. Although the level of the capital-output ratio depends on the currency unit and the base year used for the conversion to real terms, 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 unlike Japan and other neighboring countries¹².

¹⁰For 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.

¹¹PWT uses the Heston-Summers method for PPP adjustment. They have not yet updated the capital per worker series in version 6.2.

¹²Otsu (2009) shows that the postwar Japanese recovery can be attributed to the rapid capital accumulation due to the capital destruction and the growth in TFP. Young (1995) shows that the rapid growth in emerging East Asian economies during the 70s and 80s was driven mainly by rapid capital accumulation.

Labor usually 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 plot the civilian employment data from the Source OECD database as a proxy for labor input¹³. Employment per EQA in the ROW is roughly stable and slightly increases throughout the period. On the other hand, employment per EQA in China jumps up in 1990. Unfortunately, this is due to the discontinuity in the official labor statistics in China. As pointed out in Young (2003), the official data prior to 1990 is based on administrative and survey based estimates whereas the data after 1990 is based on population census conducted in 1990 and 2002. The definition of employment is looser in the population census than in the earlier surveys.

Given data of output, capital stock, 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 θ 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 EQA. 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 by extrapolating the ND (1993) data set which covers both countries. We use the perpetual inventory method with the capital law of motion

$$N_{t+1}K_{t+1} = N_t I_t + (1 - \delta)N_t K_t, \tag{1}$$

where N_t is the EQA¹⁴. 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 labor, our measure of aggregate TFP includes changes in hours worked per worker. Moreover, the employment data in China is not reliable due to the data break. Finally, capital income shares might differ across countries. This is especially problematic in aggregating TFP for the ROW. Following Gollin (2002), we assume one-third as the common capital share for the ROW and China to

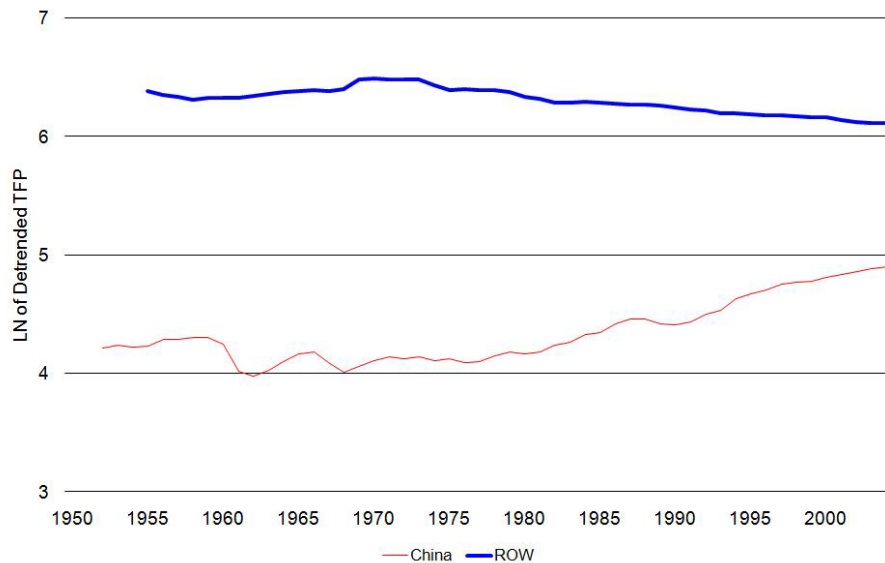
¹³For France, we use the LABORSTA database from the International Labor Organization.

¹⁴The depreciation rate is computed directly from the ND (1993) data set during the period in which capital data exists using (1). We obtain 0.032 for the ROW and 0.038 for China; we use 3.5% as the common depreciation rate in both China and the ROW for simplicity. Then we reconstruct the initial level of capital from the capital to output ratio from ND (1993) and the output data from PWT. Finally, we extrapolate the capital stock series using the investment data from PWT.

avoid this issue¹⁵.

Figure 6 plots our measure of aggregate TFP detrended with the same linear trend as in Figure 2¹⁶. 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. The amazing coincidence in the opening-up and the take-off implies that there might be a common source of these two. However, we do not explore the sources of aggregate TFP growth in this paper¹⁷. Instead, we deduce the quantitative impacts of a sudden growth in Chinese productivity on the Chinese and the ROW economies.

Figure 6. “Crude” Measure of TFP



In short, the three key features of the Chinese economy are; China suddenly opened up in 1978; output growth took off in 1978; and although the trade volume increased, there seems to be no trend in the trade balance throughout the entire period. Additional features include the gradual growth of TFP and the lack of consumption risk-sharing between China and the

¹⁵Gollin (2002) reports 0.664 as the mean labor income share in various countries in selected years after adjusting for self employment income. Unfortunately, China is not included in the sample. Young (2003) reports 0.6 as the average labor share in China over the 1978-1995 period. However, a similar adjustment as in Gollin (2002) is not possible due to the lack of supporting data. We assume that the world average capital share implied by Gollin (2002), one-third, applies for China as well.

¹⁶The ROW series starts from 1955 due to the lack of employment data.

¹⁷Young (2003) shows that inflation understatement, rising participation, labor reallocation from agriculture to non-agriculture sectors and the accumulation of human capital can account for most of the rapid growth of the measured TFP in China.

ROW. In the next section, we construct a dynamic general equilibrium model incorporating these facts in order to assess the impact of China's growth and opening-up on the ROW.

3 The Model Economy

The basis of our model is a competitive market version of a two-country two-good model à la BKK (1994)¹⁸. The two economies in the model are China and the ROW. Intermediate goods produced from internationally immobile capital and labor in each country are traded in the international goods market. Final goods in each country are produced from these intermediate goods. The countries can also trade international claims in an international asset market. The model is detrended with constant TFP growth in order to induce stationarity.

3.1 Households

The representative households in each economy $i = \{C, R\}$, which stand for China and the ROW respectively, gain utility from consumption and leisure. The households maximize their lifetime utility:

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

subject to budget constraints:

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

That is, the households receive income from labor $l_{i,t}$, capital $k_{i,t}$, lump-sum transfer $T_{i,t}$ the return on the international claim $d_{i,t}$, and profits from the intermediate good and final good firm $\pi_{i,t}$ and $\pi_{i,t}^f$, 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 the wages and the return on capital relative to domestic final goods prices. The price of international claims Q_t is common to both countries. International claims are denominated in the ROW currency. Therefore, $rer_{R,t} = 1$ and the real exchange rate $rer_t = rer_{C,t}$ is defined as the ROW final good prices relative to Chinese final good prices

$$rer_t = \frac{P_{R,t}}{P_{C,t}} \quad (3)$$

¹⁸The competitive equilibrium setting follows Raffo (2008).

. We define the growth trend as $\Gamma = (1 + \gamma)(1 + n)$ where we assume that the EQA growth rate n and the growth rate of technology on the world frontier γ are constant¹⁹. Investment is defined by the capital accumulation equation:

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

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

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

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:

$$\max \pi_{i,t} = p_{i,t}^j y_{i,t} - w_{i,t} l_{i,t} - r_{i,t} k_{i,t} \quad (4)$$

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

$$p_{i,t}^j = \frac{P_t^j}{P_{i,t}}.$$

3.3 Final Goods Firms

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

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

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

¹⁹The EQA growth rate over the entire period is 1.7 percent in China and 1.2 percent in the ROW.

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

$$\max \pi_{C,t}^f = G_{C,t}(a_{C,t}, b_{C,t}, \eta_{C,t}) - p_{C,t}^a a_{C,t} - (1 + \tau_{C,t}) p_{C,t}^b b_{C,t} \quad (5)$$

where $\tau_{C,t}$ is the tariff rate²⁰. On the other hand, we assume no tariffs in the ROW. Thus, the profit maximization problem for the ROW is

$$\max \pi_{R,t}^f = G_{R,t}(a_{R,t}, b_{R,t}, \eta_{R,t}) - p_{R,t}^a a_{R,t} - p_{R,t}^b b_{R,t}. \quad (6)$$

3.4 Government

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

$$\tau_{C,t} p_{C,t}^b b_{C,t} = T_t. \quad (7)$$

The ROW government plays no role in this model.

3.5 Resource Constraints

Resource constraints for intermediate goods are:

$$a_{C,t} + a_{R,t} = y_{C,t} \quad (8)$$

and

$$b_{C,t} + b_{R,t} = y_{R,t}. \quad (9)$$

The resource constraints for final goods in each country are

$$c_{i,t} + x_{i,t} = G_{i,t}(a_{i,t}, b_{i,t}, \eta_{i,t}). \quad (10)$$

The GDP in each country can be expressed as

$$GDP_{C,t} = p_{C,t}^a y_{C,t}, GDP_{R,t} = p_{R,t}^b y_{R,t}.$$

²⁰In the appendix, we also provide for a model in which China also uses export subsidies to promote trade.

The trade balance is derived from (2), (4), (5), (6), (7), (8), (9) and (10) as

$$\begin{aligned} tb_{C,t} &= p_{C,t}^a a_{R,t} - p_{C,t}^b b_{C,t} = rer_t (Q_t \Gamma d_{C,t+1} - d_{C,t}), \\ tb_{R,t} &= p_{R,t}^b b_{C,t} - p_{R,t}^a a_{R,t} = Q_t \Gamma d_{R,t+1} - d_{R,t}. \end{aligned}$$

In addition, the market clearing condition for claims:

$$d_{C,t} + d_{R,t} = 0$$

implies

$$tb_{C,t} + rer_t tb_{R,t} = 0.$$

which states that the trade balances of the two economies must sum up to zero²¹.

3.6 Prices

In this paper we define the terms of trade as the price of Chinese exports relative to the ROW exports:

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

The relative prices of intermediate goods are endogenously derived from the final goods firms' problems as follows:

$$tot_t = \frac{\eta_{C,t}}{1 - \eta_{C,t}} \frac{1}{1 + \tau_t} \left(\frac{b_{C,t}}{a_{C,t}} \right)^{\frac{1}{\varepsilon}} = \frac{1 - \eta_{R,t}}{\eta_{R,t}} \left(\frac{b_{R,t}}{a_{R,t}} \right)^{\frac{1}{\varepsilon}}. \quad (11)$$

Therefore, home goods weight shocks and tariffs directly affect the terms of trade. A drop in Chinese home goods weight and a rise in tariffs leads to a deterioration in the terms of trade *ceteris paribus*.

The real exchange rate is defined as the price of final goods in the ROW relative to that in China as in (3). Again, from the final goods firms' problem, we can derive the relative

²¹Since this is guaranteed by Walras' law, we do not include this in the set of equilibrium conditions when we solve the model.

prices as follows:

$$\begin{aligned}
rer_t &= \frac{P_{R,t}}{P_{C,t}} = \frac{p_{C,t}^a}{p_{R,t}^a} = \frac{\eta_{C,t}}{1 - \eta_{R,t}} \left(\frac{G_{C,t}/a_{C,t}}{G_{R,t}/a_{R,t}} \right)^{\frac{1}{\varepsilon}} \\
&= \frac{p_{C,t}^b}{p_{R,t}^b} = \frac{1}{1 + \tau_t} \frac{1 - \eta_{C,t}}{\eta_{R,t}} \left(\frac{G_{C,t}/b_{C,t}}{G_{R,t}/b_{R,t}} \right)^{\frac{1}{\varepsilon}}.
\end{aligned} \tag{12}$$

Therefore, home goods weight shocks and tariffs directly affect the real exchange rate as well. A rise in tariffs causes a depreciation in the Chinese real exchange rate. The impact of changes in Chinese home goods weight on the real exchange rate depends on the endogenous reactions of intermediate goods. The real exchange rate must also satisfy the international consumption risk sharing condition:

$$rer_t = \frac{\Psi_R c_{C,t}}{\Psi_C c_{R,t}} \tag{13}$$

where $\frac{\Psi_i}{c_{i,t}}$ is the marginal utility of consumption in each country²².

3.7 Exogenous Variables

3.7.1 Home Goods Weight

The home goods weight governs 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 Reform and Opening-up 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:

$$v_t = \frac{a_{R,t} + b_{C,t}/tot_t}{y_{C,t}}$$

²²This condition is derived from

$$\frac{\Gamma Q_{t-1}}{\beta} = \frac{rer_t}{rer_{t-1}} \frac{c_{C,t-1}}{c_{C,t}} = \frac{c_{R,t-1}}{c_{R,t}}$$

assuming

$$rer_0 = \frac{c_{C,0}}{c_{R,0}}.$$

in 1978.

Undoubtedly, the Reform and Opening-up policy in China was a huge shift in the social paradigm. As stated in Lardy (2002), prior to the opening-up the central planning government imported machinery and equipment, industrial raw materials, and intermediate goods in order to meet high priority final goods for domestic consumption. Redundant goods in the domestic markets were exported in order to finance these imports. Once the government opened-up the economy, domestic firms were allowed to import parts and components in order to assemble processed exports; foreign firms were allowed to operate in China which lead to a sharp increase of the inflow in foreign direct investment; and firms in special economic zones started to produce goods that meet foreign demand. Therefore, there was a sudden reduction in the reliance on domestic production factors in producing final goods in China and at the same time Chinese factors suddenly became available for foreign final good production. We model this dramatic shift in the trade and industrial organization policy as a change in the home goods weight²³.

3.7.2 Productivity

Productivity growth is the main source of China's output growth. One accounting issue to be noted is that the intermediate goods firm productivity in our model is not equivalent to aggregate TFP. In the 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 $p_{i,t}^j \exp(z_{i,t})$, 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.

Dekle and Vandenbroucke (2006) shows that the reallocation from agriculture to the non-agriculture sector lead to the rapid TFP growth. Young (2006) shows that the rapid productivity growth is due to the mismeasurement of inflation, and human capital accumulation. 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.

3.7.3 Import Tariffs

In this paper tariffs on Chinese imports play a key role in maintaining balanced trade, i.e. financial autarky. Lardy (2002) states that tariffs did not have important effects on imports prior to the opening-up since the government directly determined the quantities of imports.

²³ A model with export subsidies instead of variable home bias should produce similar results to our model. An export subsidy model is introduced in the appendix.

Therefore, instead of relying on existing data on tariffs, we compute the tariffs needed in order to guarantee balanced trade in the model as the shadow price of the distortions in the Chinese trade market.

Since the balanced trade constraint guarantees financial autarky, tariffs can also be interpreted as financial market disturbances such as financial transaction costs or limited access to the foreign exchange market. We show in the appendix that financial taxes in the international capital market will operate as tariffs by distorting the international first order condition (13)²⁴.

3.8 Competitive Equilibrium

The competitive equilibrium is a set of allocations and prices for $i = C, R$;

$$\{c_{i,t}, l_{i,t}, k_{i,t+1}, y_{i,t}, x_{i,t}, T_{i,t}, a_{i,t}, b_{i,t}, w_{i,t}, r_{i,t}, p_{i,t}^a, p_{i,t}^b, z_{i,t}, \eta_{i,t}, \tau_{i,t}\}_{t=0}^{\infty},$$

such that, (i) households optimize given $\{w_{i,t}, r_{i,t}, T_{i,t}\}_{t=0}^{\infty}$ and $k_{i,0}$, (ii) intermediate goods firms optimize given $\{w_{i,t}, r_{i,t}, p_{i,t}^j, z_{i,t}\}_{t=0}^{\infty}$, (iii) final goods firms optimize given $\{p_{i,t}^a, p_{i,t}^b, \eta_{i,t}, \tau_{i,t}\}_{t=0}^{\infty}$, (iv) markets clear, (v) the Chinese government budget constraint (7) holds and (vi) the resource constraints (8), (9), and (10) hold.

4 Quantitative Analysis

4.1 Parameter Values

In this paper we assume that China and the ROW are identical in the long run. Therefore, we assume symmetric steady states and structural parameters. Table 1 reports the parameter values common to both countries.

²⁴A one-to-one mapping is not possible since financial market imperfections will create a wedge between the marginal utilities across countries without distorting the terms of trade.

Table 1. Parameter Values

ε	Intermediate Good Elasticity	1.5
θ	Capital Income Share	1/3
γ	Technology Growth Rate	0.026
n	EQA Growth Rate	0.015
δ	Depreciation Rate	0.035
β	Discount Factor	0.95
Ψ	Preference Weight	0.34
z	Productivity	0
η	Home Goods Weight	0.76

The elasticity of substitution between home goods and foreign goods ε is borrowed from BKK (1994). The capital income share θ is borrowed from Gollin (2002). The technology growth rate γ is the average growth rate of the output per EQA in the ROW and the pre-reform China. The population growth is the average of the two economies values computed directly from data. The capital depreciation rate δ and discount factor β are calibrated to match the investment to capital ratio and output to capital ratio in the model to those computed from the PWT and ND (1993) datasets respectively. The consumption-leisure parameter Ψ is calibrated to match a steady state labor level of 0.3²⁵.

We assume the steady state productivity level z as 0. The steady state home goods weight η is determined by the symmetric steady state terms of trade. 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 $\tau = 0$. Therefore, from (11)

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

where

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

Thus, the steady state degree of home goods weight η can be calibrated using the import share to production b/y . The average Chinese openness over the 1978-2004 period is 0.42. However, this includes the trade with not only the G7 countries, but also the countries that are not considered in the model. According to the IMF Direction of Trade Statistics, the average Chinese trade with the G7 countries relative to that with the entire world during the same period was 0.45, which implies that the Chinese openness to G7 was 0.189. Therefore,

²⁵Steady state labor level of 0.3 implies a Frisch elasticity of labor supply of 2.33 given log preferences, which is standard in the business cycle literature.

from the domestic point of view the post reform Chinese openness was 0.42, whereas, from the G7 point of view this was 0.189. Since both are valid measures of openness in our model, we take the simple average of the two, 0.3, as the post-reform steady state openness. Given symmetry, we obtain the steady state import share 0.15, which leads to $\eta = 0.76$.

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, openness and trade balance roughly match the data. In specific, we assume that the Chinese openness jumps up from 0.1 to 0.3 in 1978 and remains at that level from then on; the detrended GDP growth rate increases from 0 percent to 5 percent after 1978 until it catches up to the ROW; and the trade is balanced throughout the entire period²⁶. The dynamic system of equations is solved using the shooting algorithm with TROLL²⁷.

We assume the post-reform openness to the ROW to be 0.3 which is the average of the Chinese openness to the entire world and that to the G7 as discussed above. The choice of 0 percent detrended growth prior to 1978 follows the assumption that China and the ROW were growing at the same speed prior to the opening-up, 2.63 percent²⁸. Since the average post-reform average output growth rate in China is 7.6 percent, the average post-reform detrended output growth rate is 5 percent.

Since the model is deterministic, the paths of exogenous variables are perfectly foreseen. It is not reasonable to assume that the agents in both economies knew that the opening-up and reform policy would occur in 1978 beforehand. Thus, we divide the whole period into two. The first period is illustrated by low openness and GDP in China. The second period starts in 1978 in which suddenly the openness and the GDP growth rate increased. This setting implies that the agents were suddenly surprised by the new path of exogenous variables and re-optimized in 1978²⁹.

First, for the 1950-1977 period, we set the level of productivity at -2.3 and home goods

²⁶Alternatively, we can use the data of output, openness and the trade balance over the 1950-2004 period and project their paths of them after 2005. The main results do not change.

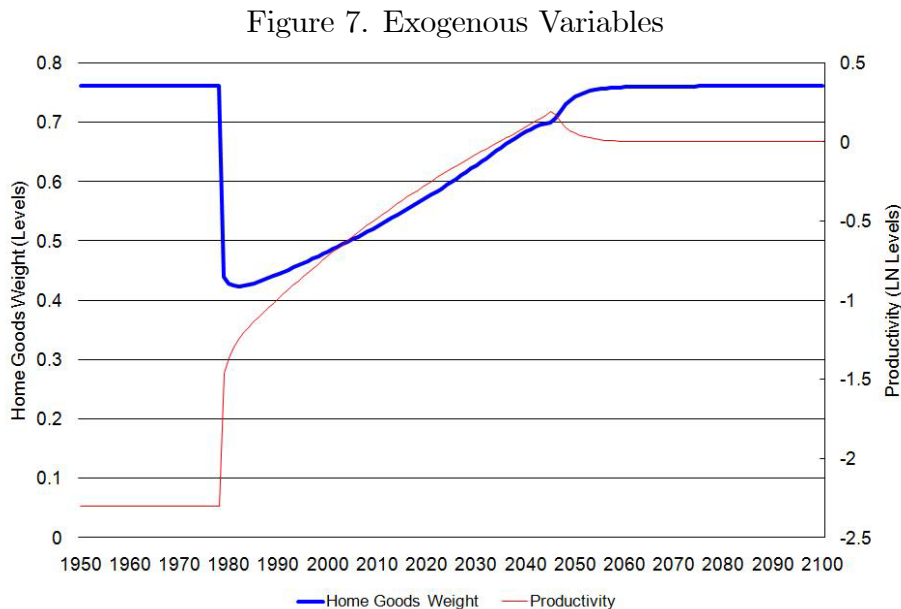
²⁷We are grateful to Naoko Hara for her invaluable help with the programming of the solution method.

²⁸This assumption largely simplifies the analysis by ignoring natural convergence without the Reform and Opening-up policy.

²⁹This is the same setting as the sudden surprise exercise in Meza and Quintin (2007) and Kehoe and Ruhl (2009).

weight at 0.76 so that Chinese GDP per EQA relative to the ROW GDP per EQA and the Chinese openness in the model matches those in the data at 0.055 and 0.1 respectively³⁰. Next, 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 at 0.3 level and detrended GDP grows at the 5 percent until it converges to the ROW level³¹.

Figure 7 shows the computed exogenous variables. Indeed, the home goods weight suddenly drops in 1978 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.



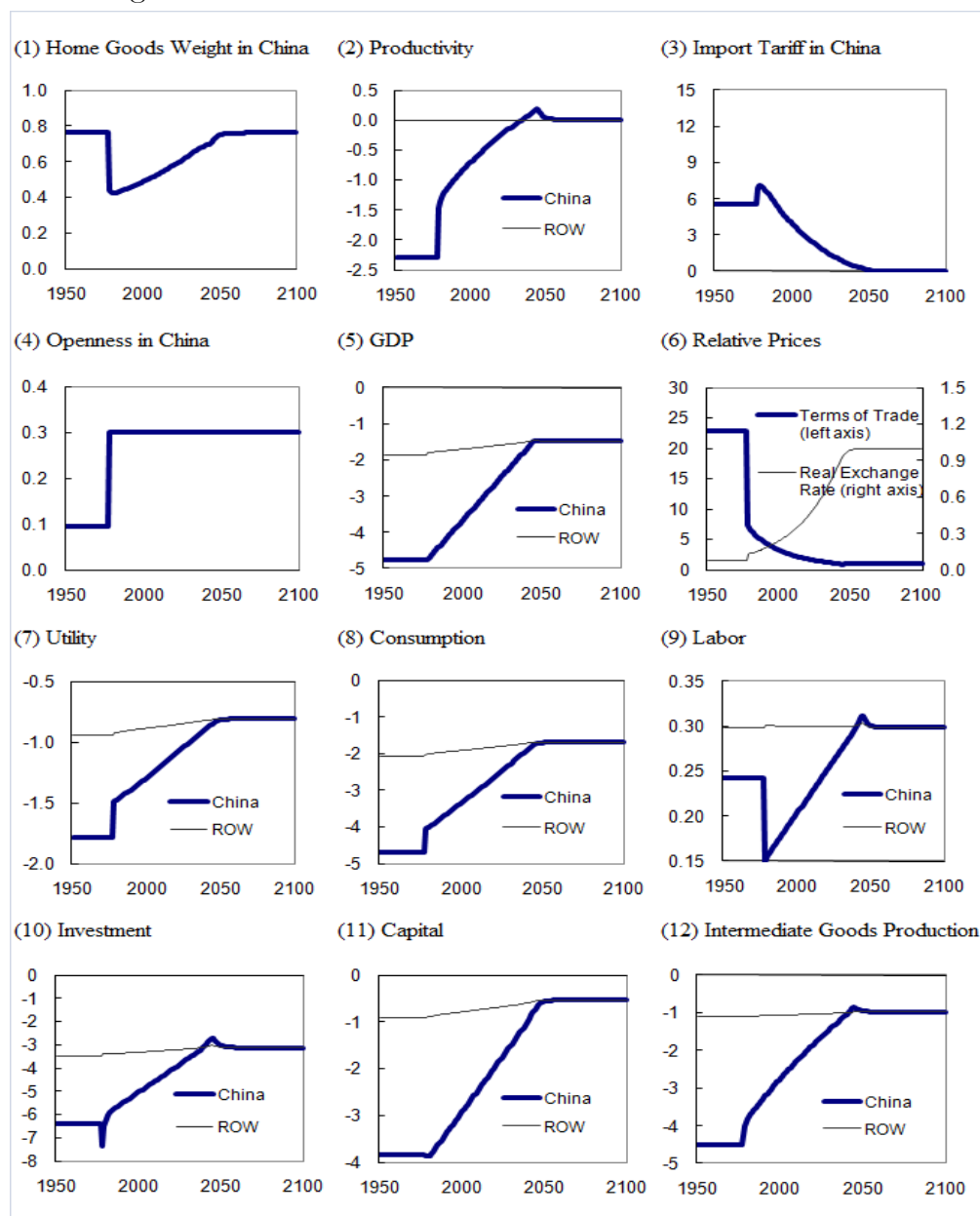
4.2.1 Benchmark Simulation

Figure 8 shows the result of the benchmark simulation of the model with both shocks while maintaining the balanced trade constraint. The home goods weight, productivity and tariffs are computed to match the time paths of the openness, GDP and trade balance in China. 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.

³⁰The fact that the initial home good weight matches that of the steady state is a coincidence. 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 opening.

³¹Changing the speed of convergence does not affect the result. We can alternatively use a smoother path of convergence for the 2004-2100 period.

Figure 8. Benchmark Simulation Results with Both Shocks



The results show that the opening-up and productivity growth in China led to a growth in output and an improvement in welfare in both economies. Consumption grows in both economies. Chinese labor and investment initially drop and gradually rise towards their symmetric steady state. Investment gradually rises in the ROW which leads to a rise in capital stock. The results also indicate that the Chinese real exchange rate should continue to depreciate until they reach the symmetric steady state. The mechanisms through which each exogenous variable operates are discussed in the following sections.

Variables such as investment, labor and consumption in China directly inherit the jumps in home goods weight and productivity in 1978. We conjecture that the discrepancy between actual data and the model prediction is due to the sluggish adjustment process of a central planning government. Despite the rapid opening-up, in 1978 the majority of the economy was not operating through the market but was controlled by the government. The central planning government might prefer rolling-over the resource allocation from the previous period rather than using resources to reoptimize according to shifts in demand and supply. Adjustment costs on consumption, labor and investment are sensible assumptions to account for this sluggishness. In addition, the perfect foresight model creates large income effects in the reform period since the Chinese agents suddenly realize the rapid growth in the future. A stochastic model should decrease the jumps in these variables to some extent.

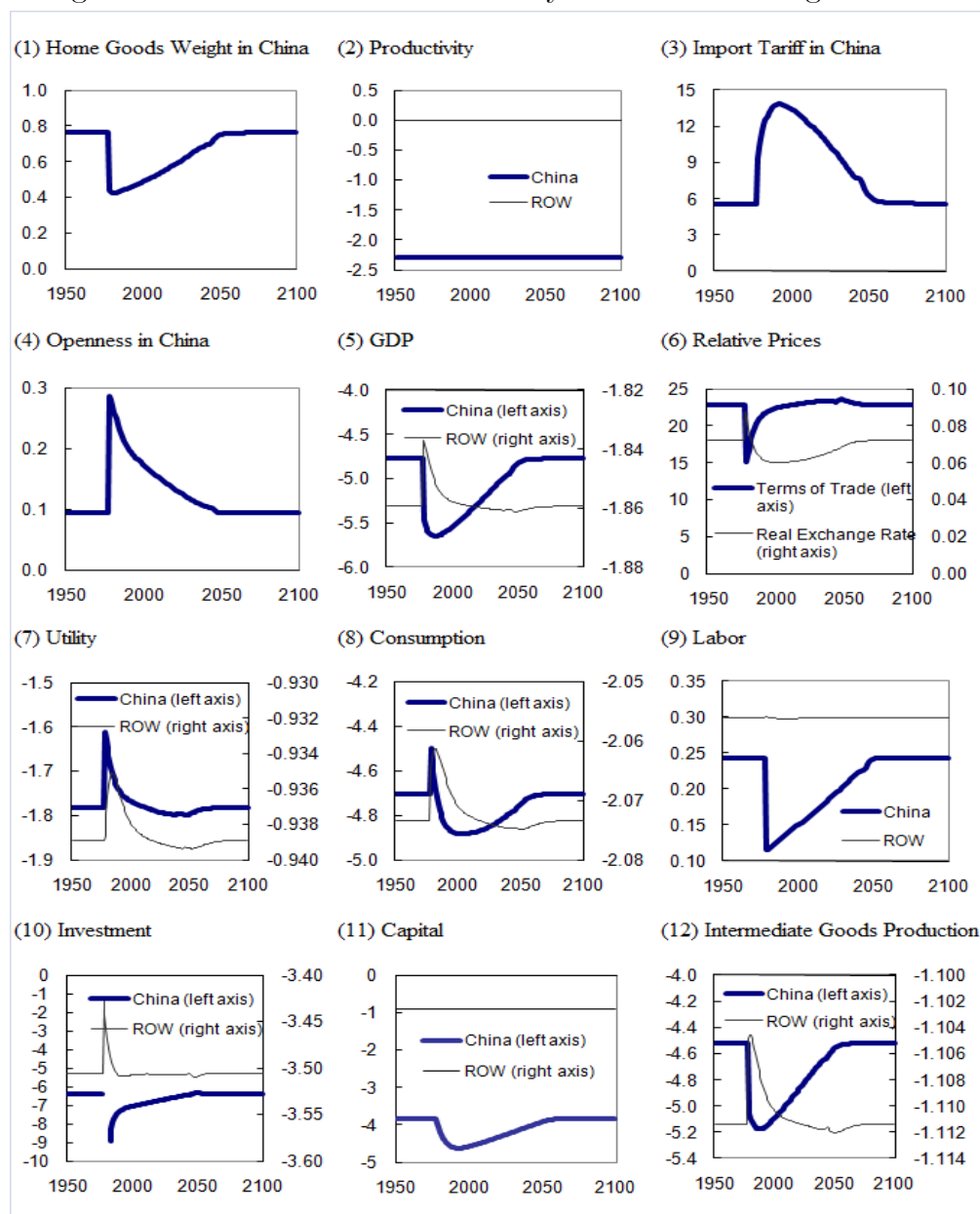
Moreover, the model predicts a gradual growth in post-reform detrended output, consumption and investment in the ROW, while they were actually declining in the data. The main reason of this discrepancy is because we set the ROW productivity growth constant in our simulation. As shown earlier, the crude TFP growth is slowing down in the ROW after the oil shock in 1974, which suggests that the intermediate good firm productivity growth in the ROW was slowing down as well. Allowing the ROW productivity to fluctuate over time should address this issue. However, since our main focus of this paper is to understand the impact of the exogenous variables in China, we do not further complicate the analysis.

4.2.2 Simulation with only Home Goods Weight Shocks

Figure 9 presents the results of the counterfactual simulation with home goods weight shocks keeping productivity constant at its initial level while maintaining the balanced trade constraint³².

³²It is crucial for our analysis to remain the balanced trade constraint for each counterfactual simulation since the removal of it will lead to an immediate jump in endogenous variables due to the income effect. This is discussed in detail in the following section.

Figure 9. Simulation Results with only 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 declines following the drop in investment. Consumption initially increases since the trade account remains balanced while investment falls more than output does, but gradually falls following the decline in capital stock. As the home goods weight returns to the initial level, the economy gradually goes back to the initial level. Tariffs are high throughout the period since productivity remains

low. This implies that China is better off running a trade deficit while their income is below the steady state and the government is imposing high tariffs to prevent it. The Chinese real exchange rate initially depreciates and gradually converges to its initial state.

The increase in the world demand for b leads to an improvement in the terms of trade in the ROW. Consumption increases due to the positive income effect. Furthermore, the ROW increases labor and investment in order to produce more. However, the effect of this shock is relatively small in the ROW since the China initially is very small relative to the ROW.

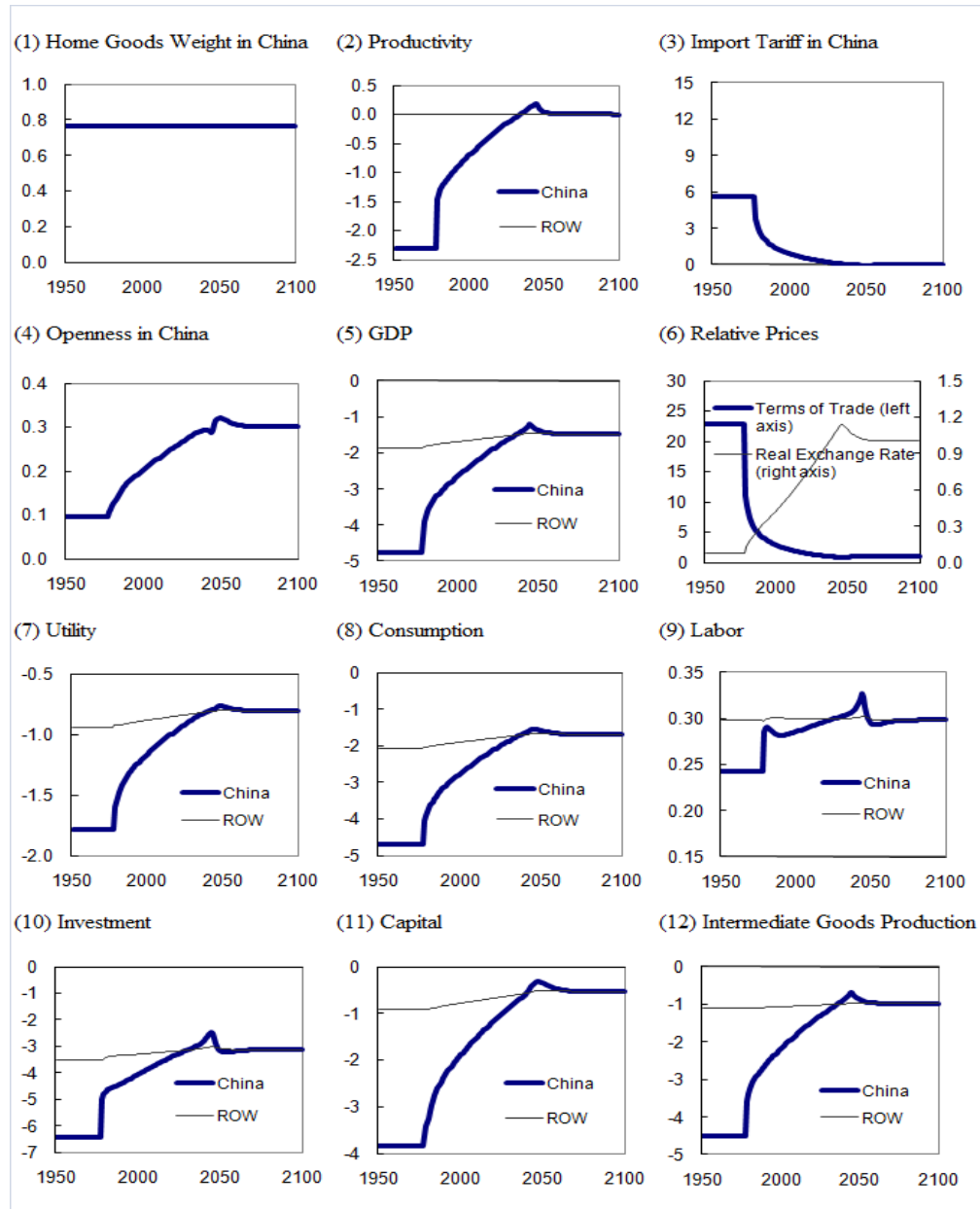
4.2.3 Simulation with only Productivity Shocks

Figure 10 shows the results of the counterfactual simulation with only productivity shocks keeping the home goods weight constant at its initial level while maintaining the balanced trade constraint.

As in a standard neoclassical growth model, a long-run increase in productivity causes China's output, investment and consumption to increase. Tariffs are initially high to prevent China from running a current account deficit as in the previous case while they gradually decline and eventually disappear as the Chinese productivity level converges to the symmetric steady state. China's labor is initially below the ROW level and gradually converges to the symmetric steady state level as the productivity gap and tariffs vanish. China's utility rises as productivity increases, which implies that the effect of the increase in consumption on welfare outweighs the effect of the increase in labor. The Chinese real exchange rate gradually depreciates and converges to the symmetric steady state as the price level in China falls due to the increase in production capacity.

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 supply of good a increases so its relative price falls. The improvement in the terms of trade in the ROW leads to an increase in output, consumption, investment and labor. As in China, the utility in the ROW increases. The impact on the ROW is significant because the impact of China's productivity growth increases as its country size increases.

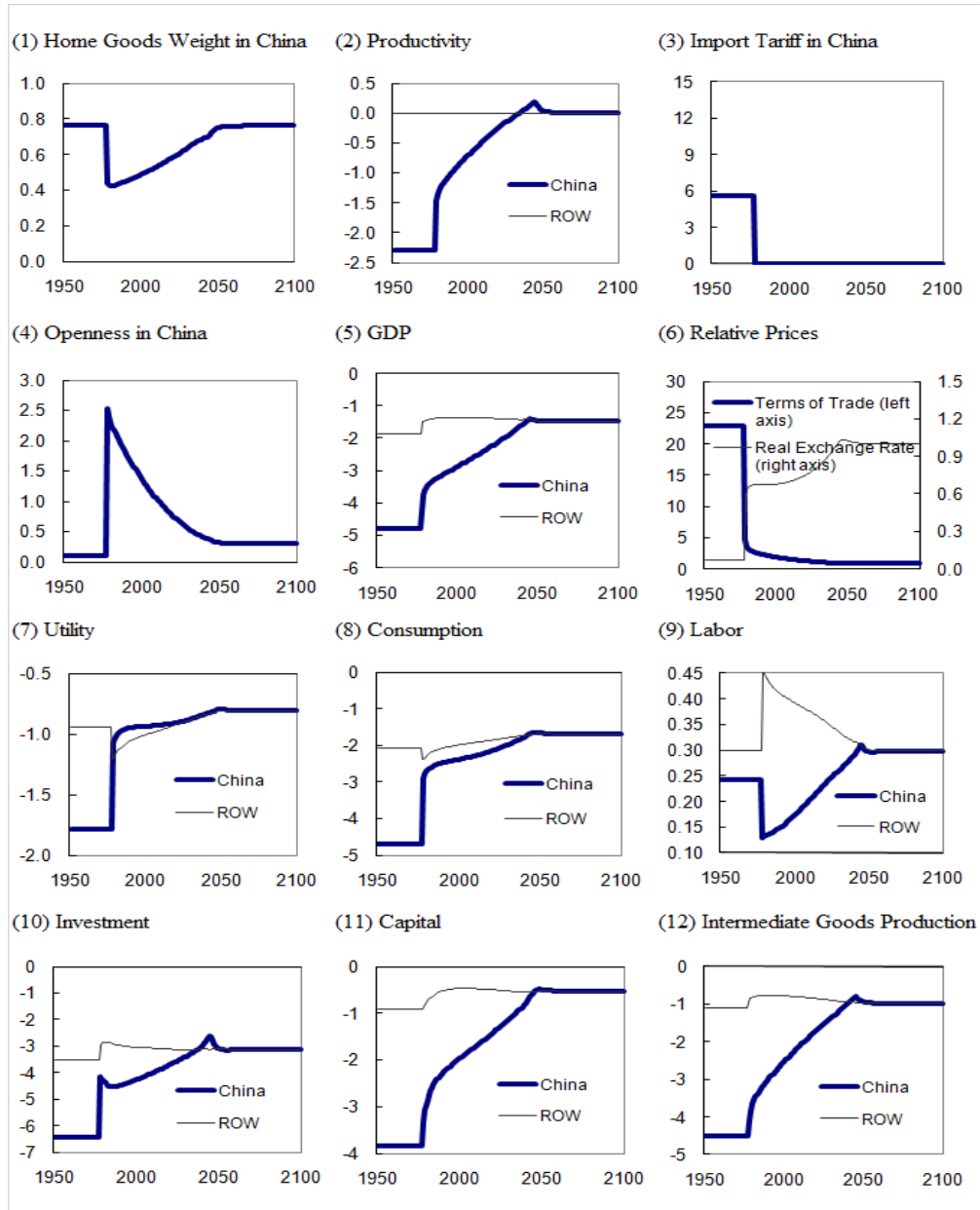
Figure 10. Simulation Results with only Productivity Shocks



4.2.4 Simulation without the Balanced Trade Constraint

In this section we consider a counterfactual case in which the Chinese government removes the balanced trade constraint after the opening-up in order to assess its role. In specific, we assume zero tariffs from 1978 on which allows the trade balance to fluctuate. The results are plotted in Figure 11.

Figure 11. Simulation Results with Both Shocks
without the Balanced Trade Constraint



The removal of the balanced trade constraint in 1978 has an immediate effect on both economies. Without the balanced trade constraint China will run a trade deficit in order to borrow and smooth consumption given the growth in the future income. Therefore, imports of foreign goods increase and purchases of home goods decrease in China. As a result, the household in China works less and consumes 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. In addition, the ROW cuts back on consumption in order to export goods to China. Therefore, although its GDP increases, the ROW is temporarily worse off due to the removal of the balanced trade constraint. The channels through which each shock operates after the reform are the same as in the benchmark case.

This result is related to the so called Lucas Paradox pointed out by Lucas (1990). That is, contrary to the prediction of the simplest neoclassical growth model, capital does not flow from capital rich countries to capital scarce countries. One explanation to this paradox is that the productivity difference compensates the difference in capital stock levels so that the marginal product of capital is not so different across countries, which prevents capital flow into poor countries³³. In our model, in fact, the initial productivity difference more than compensates the capital scarcity in China³⁴. The reason why capital flows into China in our free trade case is because of the perfect consumption insurance contract. Since the consumption level is much lower in China than in the ROW in earlier periods, the ROW is forced to temporarily lend resources to China in order to equate the international marginal rate of substitution.

4.2.5 Welfare Analysis

In order to further assess the effect of each shock on consumers' welfare, we compute the welfare improvement in both countries for each simulation. 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

$$WI = \sum_{t=1978}^{2100} \beta^t [u(c_t, 1 - l_t) - u(c_{1977}, 1 - l_{1977})].$$

³³Lucas (1990) shows that despite the low level of physical capital, the marginal product of capital in India is somewhat equivalent to that in the U.S. due to the difference in the human capital accumulation. Therefore, capital should not necessarily flow from the U.S. into India.

³⁴The productivity and capital stock levels in China are 10% and 3.7% relative to those in the ROW prior to the opening-up. The marginal product of capital in China can be written as

$$p_{C,t}^a z_{C,t} k_{C,t}^{\theta-1} l_{C,t}^{1-\theta}.$$

The effect of capital scarcity on the marginal product of capital is $0.037^{-2/3} = 9$. Therefore, the capital scarcity makes the Chinese marginal product of capital nine times higher than that in the ROW whereas low productivity makes it ten times lower.

Table 2 lists the welfare improvement computed from simulations with both shocks; with only home goods weight shocks; and with only productivity shocks, respectively³⁵. We also convert the welfare improvement into a percentage increase in the permanent consumption level \bar{c} from the 1977 consumption level that gives an equivalent increase in the present value discounted utility as WI :

$$\hat{c} = \log \bar{c} - \log c_{1977} = \frac{WI}{\Psi} \frac{1 - \beta^N}{1 - \beta},$$

where $N = 122$ is the number of periods from the opening-up in 1978 to the terminal period 2100³⁶. These are reported in the parentheses.

Table 2. Welfare Analysis

With Balanced Trade Constraint			
	Both Shocks	Home Goods Weight	Productivity
China	8.31(122%)	0.95(14%)	9.52(140%)
ROW	0.82(12%)	0.03(0%)	0.84(12%)
No Balanced Trade Constraint			
	Both Shocks	Home Goods Weight	Productivity
China	14.94(220%)	12.29(181%)	11.29(166%)
ROW	-1.92(-28%)	-3.72(-55%)	-0.21(-3%)

Overall, both China and the ROW are better off due to the opening-up and growth of China in the benchmark case. The welfare improvement is significant in the ROW as the permanent consumption level increased by 12%. 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 decimal. Both China and the ROW are significantly better off due to the growth in Chinese productivity.

The results from the simulation without the balanced trade constraint indicate that while China is better off, the ROW is worse off after removing the tariffs. It is surprising that the ROW is worse off even with the productivity growth in China alone. Although the ROW reaches a higher level of output, capital, and consumption in the long run, overall

³⁵The results with both shocks are not simple sums of those with individual shocks since the model is solved with a non-linear method and the individual simulations assume balanced trade in each case, which implies different tariffs for each simulation.

³⁶Extending the sample period from 122 years to infinity will not change the quantitative results much because of the discounting.

it is worse off due to the initial drop in consumption and leisure. The loss in the ROW welfare with both shocks is equivalent to a drop in the permanent consumption level as large as 28%³⁷. Nonetheless, the total world welfare is higher under this free trade scenario than in the benchmark case because the welfare gain in China is greater in the former case. In other words, the Chinese balanced trade policy was actually welfare improving for the ROW and welfare deteriorating for China within a simple neoclassical model with complete markets. Therefore, from the ROW point of view, a gradual decline in Chinese tariffs during its catch-up process is preferable to a drastic trade liberalization.

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 with complete markets. We consider our model as a foundation to understand the impact of the sudden opening-up of China. We showed that a gradual productivity growth, sudden drop in home goods weight, and tariffs in China can account for the rapid output growth and the sudden increase in openness while maintaining trade balanced in China. Our counterfactual simulation 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. These imply that the Reform and Opening-up policy was welfare improving for both economies if it led to significant productivity growth in China. 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. Therefore, the balanced trade constraint helped the ROW rather than China. Thus, we conclude that a gradual trade liberalization is preferable to a drastic one from the ROW perspective.

One criticism against our approach should be the validity of modeling China as a market economy throughout the post 1950 period. Clearly, the Communist Party was controlling the economy back then; not the market mechanism. However, if a benevolent social planner is solving the optimization problem for the entire economy, the resulting resource allocation should be the same as that of a market economy. The deviations of reality from the social optimum can be considered as government failures in the social planners problem whereas

³⁷One caveat is that our model does not consider the cost of unemployment in our welfare calculation. The removal of the Chinese balanced trade constraint could improve the welfare in the ROW if the cost of unemployment is significantly reduced.

it can be considered as distortions and market failures in the market economy. We used a competitive market structure in order to introduce the balanced trade constraint as economic tariffs for modeling and computational convenience. Alternatively we could have constructed a central planning economy model with a physical constraint on the trade balance, which should produce the same result. Several government failures which we do not consider in our paper can also be mapped into a decentralized model. For instance, a social planner will have to process a huge amount of information in order to optimize and reallocate resources when it faces various shocks. This can be expressed as labor, capital and consumption adjustment costs in a decentralized model.

Our results have several policy implications. First, it is puzzling why China did not immediately engage in free trade after the opening-up, which would have made them better off. One possible explanation is that China protected its domestic industry from international competition to buy some time to adopt foreign technology. Another explanation would be that the Chinese financial market was underdeveloped and institutional deficiencies prevented capital to flow from the ROW into China. Moreover, the recent global imbalance issue is puzzling from our perspective. Under free trade, according to a simple neoclassical model with complete markets, China still should be running a trade deficit since it has a large incentive to borrow. If the Chinese government is imposing a tight constraint on goods or financial trade to achieve a large trade surplus against the ROW, it is not helping China but instead it is helping the ROW. Finally, the Chinese opening-up may have led to productivity growth. For instance, the opening-up removed the technological barrier between the ROW and China, and led to gradual productivity growth in China³⁸. Alternatively, if the imported capital goods from abroad convey cutting-edge technology as assumed in Gilchrist and Williams (2004), the increase in imports itself causes productivity growth. While these issues are beyond of the scope of this paper, we believe that future research should address them.

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³⁸Parente and Prescott (1994) and Eaton and Kortum (1997) considered this mechanism in accounting for the post war rapid growth in Japan.

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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

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

Also, the government budget constraint changes accordingly to

$$\tau_{C,t}p_{C,t}^b b_{C,t} + s_{C,t}p_{R,t}^a a_{R,t} = T_t.$$

The terms of trade in this model is

$$tot_t = \frac{\eta_C}{1 - \eta_C} \frac{1}{1 + \tau_t} \left(\frac{b_{C,t}}{a_{C,t}} \right)^{\frac{1}{\varepsilon}} = \frac{1 - \eta_R}{\eta_R} (1 - s_{C,t}) \left(\frac{b_{R,t}}{a_{R,t}} \right)^{\frac{1}{\varepsilon}}.$$

An increase in subsidies tends to deteriorate the terms of trade for China like that in tariffs does. The difference between the two are that tariffs primarily affect the intermediate goods allocation in China while subsidies primarily affect that in the ROW. The real interest rate is

$$rer_t = (1 - s_{C,t}) \frac{\eta_C}{1 - \eta_R} \left(\frac{G_{C,t}/a_{C,t}}{G_{R,t}/a_{R,t}} \right)^{\frac{1}{\varepsilon}} = \frac{1}{1 + \tau_t} \frac{1 - \eta_C}{\eta_R} \left(\frac{G_{C,t}/b_{C,t}}{G_{R,t}/b_{R,t}} \right)^{\frac{1}{\varepsilon}}.$$

An increase in subsidies tends to appreciate the real exchange rate in China like that in subsidies does.

Assume that 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 should 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.

B Financial Tax Model

Instead of tariffs, we can model the balanced trade constraint as a constraint on financial transactions. Assume that the Chinese government levies financial tax $\phi_{C,t}$ on the purchase or issuance of the international claim made by domestic agents. The budget constraint of the Chinese household will be

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

The government budget constraint changes to

$$\phi_{C,t}rer_{C,t}Q_t\Gamma d_{C,t+1} = T_t.$$

The international consumption risk sharing condition for this model is

$$\frac{\Gamma Q_{t-1}}{\beta} = \frac{1}{1 + \phi_{C,t-1}} \frac{rer_t}{rer_{t-1}} \frac{c_{C,t-1}}{c_{C,t}} = \frac{c_{R,t-1}}{c_{R,t}},$$

which reduces to

$$rer_t = \prod_{s=0}^{t-1} (1 + \phi_{C,s}) \frac{c_{C,t}}{c_{R,t}}$$

assuming $rer_0 = \frac{c_{C,0}}{c_{R,0}}$. An increase in the financial tax leads to an appreciation in the Chinese real exchange rate.

Consider a situation in which China imposes an extremely high financial tax that prevents households to trade the international claim so that $d_{C,t} = 0$. Since there will be no international financial transaction, or in other words the economies are in financial autarky, the capital account in each country will be balanced in each country. Therefore, the trade account will also be balanced. The change in the financial tax will affect the intermediate goods allocation through its effect on the real exchange rate in (12). One difference between this model and the model in the paper is that financial taxes do not have a direct impact on the terms of trade. Moreover, the model in the paper is much easier to solve since the international consumption risk sharing condition (13) does not depend on the history of financial taxes.