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Abstract

China's recent performance in economic growth was characterized by high investment rate, increase in international trade, strong productivity growth in agriculture and nonfarm sectors and the reallocation of labor across sectors. We present a standard dynamic general equilibrium model of structural transformation for the Chinese economy to assess the contributions of the main drivers for the Chinese economic development. Our paper differs from other contributions to the literature by adding an external sector to the general equilibrium model of structural transformation. By doing that, we are able to estimate the contribution of trade to the economic development of China. We estimate that the contribution of trade to China's economic growth was 26% of total economic growth during the period from 1980-2005. Moreover, the agricultural sector explained 27% of Chinese economic performance from 1980 to 2005.

Key words: China, Structural Transformation, Trade.

JEL classification: F1; O1

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1 Introduction

China's recent performance in economic growth has been unique. The country experienced a long period of stagnation followed by one of extremely rapid growth. For instance, if we extrapolate the trends exhibited over the previous decade, China will overtake Japan in 16 years in per capita terms. Only 16 years ago, China's GDP per capita was less than 15% of that in Japan. Since 1978, China's per capita GDP has grown at more than 7% annually, arguably the "most sustained period of rapid economic growth in human history" (Naughton, 2007).

One possible interpretation is that until 1979, when institutional and economic reforms began, the country suffered from a "malthusian trap", with stagnation or extremely slow growth. Since 1980, China has experienced "modern growth", characterized by rapid growth and convergence with the developed world. This is compatible with "Barriers to Riches" theory (Parente and Prescott, 2000), which states that institutional or political barriers prevent growth. It is also compatible with "Unified Growth" theories (e.g., Hansen and Prescott (2002), Galor and Weil (2002)), and hence China would be experiencing its own industrial revolution.

In addition to the significant acceleration of growth, other factors also characterized the development of the Chinese economy in recent decades. International trade has increased significantly with the sum of exports and imports increasing from less than 9% of GDP in the seventies to close to 60% at present. Capital accumulation in the nonagricultural sector increased substantially, and the growth of Total Factor Productivity (TFP) was significant in the agricultural sector. Furthermore, there was reallocation of labor from the agricultural sector to nonagricultural sectors, which allowed greater gains in aggregate productivity of the economy in the period.

This environment was conducive to a significant acceleration of economic growth in China. Labor productivity in the nonfarm sector was higher than in the agricultural sector in part because nearly all capital accumulation in the economy has occurred in the former sector. The implementation of economic reforms, which led to the reallocation of labor across sectors, and the high TFP growth in the agricultural sector fostered China's economic growth.

The objective of this article is to quantify the contributions of the main drivers of Chinese economic growth, namely: a high investment rate, the strong productivity growth in each sector and the reallocation of labor across sectors. To do so, we present a standard dynamic general equilibrium model of the structural transformation of the Chinese economy. In our model, labor reallocation across sectors is a consequence of our assumption, common to standard models of structural transformation, that the income elasticity of the agricultural good is less than unity[1].

The literature on the structural transformation of the Chinese economy is extensive. Several articles, e.g., Birchenall and Cao (2013), Dekle and Vandenbroucke (2012) and Brandt and Zhu (2010), have examined the role of the reallocation of labor across sectors during the reform period, when the Chinese economy experienced high growth rates. While most articles assign substantial importance to the process of labor reallocation from agriculture to other sectors of China's economy, the conclusions regarding the magnitude of this contribution are mixed. For example, Brandt and Zhu (2010) conclude that high TFP growth in the nonagricultural sector was the main driver of Chinese growth, while Birchenall and Cao (2013), however, note that the rapid TFP growth in the agricultural sector was responsible for the pattern of strong output growth in the Chinese economy.

Our paper differs from other contributions to the literature by adding an external sector to the general equilibrium model of structural transformation. In models of closed economies, the difference in total factor productivity growth between the agricultural and nonagricultural sectors is an important driver of the trend in the relative price of the agricultural good. A higher (lower) rate of TFP growth in the agricultural sector relative to TFP growth in the nonagricultural sector implies a decrease (increase) in the relative price of the agricultural good. As a result, closed economy models tend to overestimate the reallocation of labor from agriculture to the nonfarm sector. In contrast, open economy models, which assume that the relative price of the agricultural good is exogenous, can suitably replicate the reallocation of labor across sectors observed in the post-reform period. This follows from the observation that the relative price of the agricultural good, measured by the ratio of the deflators in rural and urban areas, remained relatively stable from 1980 to 2005, unlike the path of the relative price of the agricultural good forecasted by the closed economy model.

The article is organized into six sections in addition to this introduction. In the next section, we present stylized facts that will guide our analysis, while Section 3 presents the model. In Section 4, we discuss the calibration procedures, while sections 5 and 6 present results and counterfactual simulations. Finally, Section 7 concludes.

[1] This assumption ensures that the model is able to replicate Engel's law, a finding in economics stating that as income rises, the proportion of income spent on food falls, even if actual expenditures on food increase.

2 Stylized facts

Certain stylized facts characterize the development of the Chinese economy in recent years, for example, the significant growth in China's per capita output. The figure below presents China's GDP per capita from 1929 to 2011, using World Development Indicators (WDI) data. It is clear from the figure that until the end of the seventies (and since at least 1929) China grew at an extremely slow rate. The rate of economic growth accelerates thereafter. Relative to the USA, China's GDP per worker increased from 3.4% in 1979 to 19.8% in 2007. China's TFP increased from 20% of US TFP in 1980 to 60% in 2007 (3.9% per year).

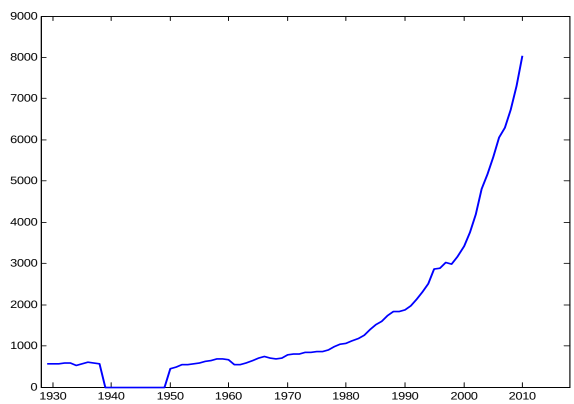

Figure 1: GDP per capita (US$ current)

A striking feature of the Chinese economy between 1980 and the present is the rapid capital accumulation over the period. This was only possible because of the high savings rate in the Chinese economy throughout the period. For example, the savings to GDP ratio increased from 36% in 1982 to 52% in 2011. However, this high savings rate is a recent feature of the Chinese economy. In the early years following China's economic reforms, the savings to GDP ratio increased from 36% in 1982 to 43% in 1994 and decreased to 37% in 2000. The savings to GDP ratio has only increased significantly in recent years, from 2001 to 2011.

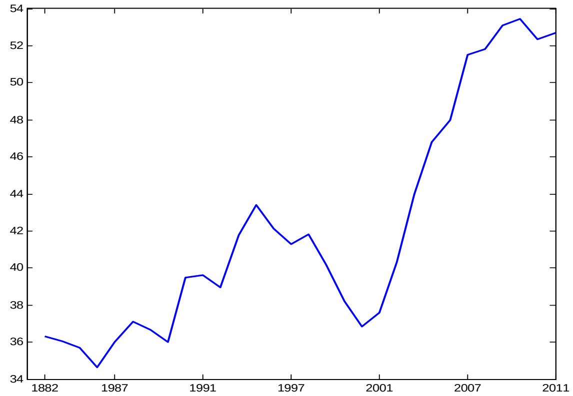

Figure 2: Savings as percentage of GDP

China experienced a rapid growth in foreign trade during the period considered, which coincided with accelerated growth. From the figure below, one can see that trade was relatively stagnant until 1979, and thereafter that both imports and exports grew continuously. For instance, the measure of the Chinese economy's trade openness (which considers the sum of imports with exports) increased from 5.3% of GDP to 58.7% in 2011, with exports accounting for 31.4% of GDP and imports 27.3% of GDP in 2011.

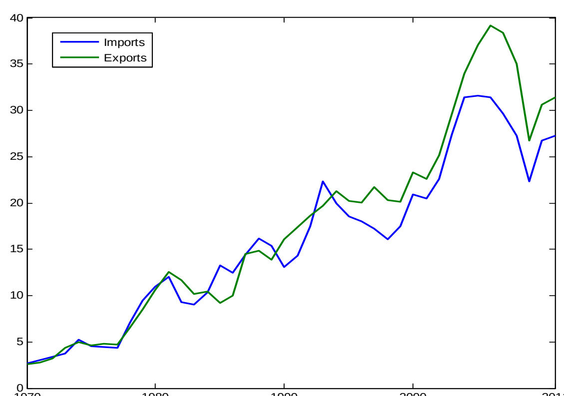

Figure 3: Imports and exports (% of GDP)

The employment share of Agriculture fell from approximately 80% in 1960 to 71% in 1978, 60% in 1990 and less than 50% in approximately 2005. However, it is still considerably higher than in other countries experiencing "economic miracles", and the rural population remains in the majority: according to the WDI (2009), in 2008 only 43% of the population lived in urban areas, compared to 56% in South Korea in 1980, when its GDP per capita was similar to that of China today[2]. As the percentage of workers employed in agriculture is still high compared to other emerging economies, this process of reallocation of labor across sectors of activity is likely continue to be an operative force in the development of the Chinese economy in the coming years. However, in terms of value added, China's structural transformation is far more advanced, and only 10% of value added in the country is from agriculture, compared to 40% in 1960. However, the share of total value added from industry remained nearly constant during this period and much higher than what is observed for other emerging economies.

Figure 4: Employment per sector (% of total)

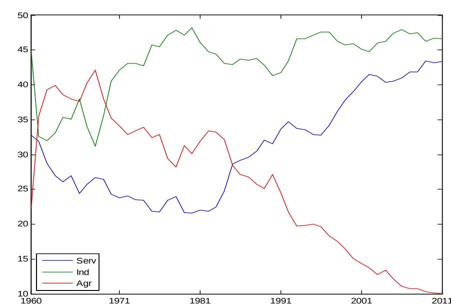

Figure 5: Value added per sector (% of GDP)

Thus, the changes in the Chinese economy between 1980 and the present stand out: strong growth in per capita output, which was made possible by the significant productivity growth during the period considered; high capital accumulation, due to the high savings rate in the economy; the openness of the economy, which led to a growth in exports that exceeded import growth; and, finally, the productivity gains arising from the labor relocation process, present during the development of most economies, which allowed the displacement of labor from less productive sectors (agriculture) to higher productivity sectors (manufacturing and services).

[2] A possible explanation is the legal limits on rural-urban migration still present in China.

3 Model

In this section, we provide a brief description of the standard structural transformation model and define the equilibrium for both closed and open versions of the model. The next step is to calibrate the structural parameters of our theoretical economy and simulate paths for prices and aggregates of this economy during the post-reform period of the Chinese economy (from 1980 to 2005). Using the calibrated model, we perform some counterfactual exercises to estimate the contribution of the agricultural sector to the path of aggregate output.

3.1 General description

Time is discrete with an infinite horizon $t = 0, ..., \infty$. The representative household is provided with one unit of time per period. Household preferences are defined over two goods: a farm good a and a nonfarm good m (manufacturing and services). The representative household is endowed with one unit of labor time, which is supplied inelastically. Of its labor income, in each period the household decides how much to consume of each good and how to divide its savings between capital and land. The price of the agricultural good is denoted by p_t. The stock of land is fixed at 1 and is owned by the household. The nonagricultural good is produced using capital and labor, with capital depreciating at rate δ, and the agricultural good is produced with capital, labor and land (which does not depreciate, is priced at q_t and its rent is r_l). Good a is exclusively used for consumption, while good m is used for consumption and capital accumulation.

3.2 The household

The household's preferences are characterized by:

$$\sum_{t=0}^{\infty} \beta^t \left[\gamma \ln\left(c_{mt}\right) + (1-\gamma) \ln\left(c_{at} - \bar{c}_a\right)\right] \tag{1}$$

where c_{at} and c_{mt} are the flows of consumer goods, and $\bar{c}_a$ is the subsistence level of the agricultural good. This assumption is in line with the literature on structural transformation (e.g., Duarte and Restuccia, 2005) and is used here to ensure that the model can match the share of workers employed in the agricultural sector in 1980. As noted above, this assumption makes the income elasticity of the agricultural good less than 1, i.e., the higher the income of the representative household, the lower the share of the household budget spent on food. In each period, the household budget constraint is given by:

$$c_{mt} + p_t c_{at} + s_{t+1} = w_t + (1 + r_t)\, s_t \tag{2}$$

where s_{t+1} is household savings in period t.

Is straightforward to demonstrate that the first order conditions for the household's problem are as follows:

$$[c_{mt}] : \beta^t \frac{\gamma}{c_{mt}} = \lambda_t$$

$$[c_{at}] : \beta^t \frac{1-\gamma}{c_{at} - \bar{c}_a} = \lambda_t p_t$$

$$[s_{t+1}] : 0 = \lambda_t - \lambda_{t+1}(1 + r_{t+1})$$

where λ_t is the Lagrange multiplier associated with the budget constraint in period t. Manipulating the above equations, we have the following relationships:

$$\frac{c_{mt}}{p_t c_{at}} = \frac{\gamma}{1-\gamma}\left(1 - \frac{\bar{c}_a}{c_{at}}\right)$$

$$\frac{c_{mt+1}}{c_{mt}} = \beta\,(1 + r_{t+1})$$

The first equation demonstrates that when consumption of the agricultural good increases, spending on the nonfarm good increases more rapidly than spending on the agricultural good. The last equation is the standard Euler equation, which relates the choice of how much of the nonagricultural good to consume in periods t and $t+1$.

3.3 The firms

The technology in the agricultural sector is such that the firms in the agricultural sector combine labor n_a, land l and capital k_a to produce an agricultural good denoted y_a. In this economy, the supply of land is assumed to be fixed, and its total size is normalized at 1. The technology in the agricultural sector is given by:

$$y_{at} = z_{at} k_{at}^{\mu} n_{at}^{\phi}$$

where $\mu, \phi \in (0,1)$ and $\mu + \phi \in (0,1)$.

In the nonagricultural sector, the firms only combine labor n_m and capital k_m to produce a manufactured good denoted y_m. The technology in this sector is given by:

$$y_{mt} = z_{mt} k_{mt}^{\alpha} n_{mt}^{1-\alpha}$$

where $\alpha \in (0,1)$ is the share of capital. The variables n_{it} and k_{it} $(i = a, m)$ represent the employment and capital stocks in sector i. The variables z_{mt} and z_{at} are exogenous and represent the Total Factor Productivity of each sector.

Firms behave competitively to maximize their profits, taking the wage rate w, the rental rate for capital r_k $(= r_t + \delta)$, and the rental rate for land r_l as given. Formally, the firm's problem in each sector can be written as follows:

$$\max_{k_{at}, n_{at}} y_{at} - (r_t + \delta) k_{at} - w_t n_{at} \tag{3}$$

$$s.t.\ y_{at} = z_{at} k_{at}^{\mu} n_{at}^{\phi}$$

$$\max_{k_{mt}, n_{mt}} y_{mt} - (r_t + \delta) k_{mt} - w_t n_{mt} \tag{4}$$

$$s.t.\ y_{mt} = z_{mt} k_{mt}^{\alpha} n_{mt}^{1-\alpha}$$

The first order conditions for profit maximization are:

$$\alpha z_{mt} k_{mt}^{\alpha-1} n_{mt}^{1-\alpha} = r_t + \delta$$

$$p_t \mu z_{at} k_{at}^{\mu-1} n_{at}^{\phi} = r_t + \delta$$

$$(1-\alpha)\, z_{mt} k_{mt}^{\alpha} n_{mt}^{-\alpha} = w_t$$

$$p_t \phi z_{at} k_{at}^{\mu} n_{at}^{\phi-1} = w_t$$

In addition, the rental fee of the land can also be calculated as:

$$(1-\mu-\phi)\, z_{at} k_{at}^{\mu} n_{at}^{\phi} = r_{lt}.$$

Combining the above equations, we have:

$$\frac{n_{mt}}{n_{at}} = \frac{1-\alpha}{\alpha}\frac{\mu}{\phi}\frac{k_{mt}}{k_{at}} \tag{5}$$

The equation above defines an efficient condition for the allocation of inputs (k_{at}, n_{at}), given the stock of capital k_{mt} and the labor share n_{mt} in period t. This relationship defines the allocation of labor and capital in each sector and, given an initial capital stock and the law of motion of capital, defines how much capital and labor are allocated to each sector for all periods of the simulation.

In addition to the equations derived from the representative household's problem and the profit maximization of firms, the following conditions must be satisfied:

$$s_{t+1} = k_{at+1} + k_{mt+1} + q_t$$

$$1 + r_{t+1} = \frac{r_{lt+1} + q_{t+1}}{q_t}$$

The first equation indicates that the savings of the representative household can be allocated to capital in the agricultural sector, capital in the manufacturing sector and land. The land price is denoted q_t. In the second equation, we have the no-arbitrage condition between the two assets (capital and land) where the gross rate of return should equal the gross return of land. In addition, we have implicitly assumed that the rate of return on physical capital should be identical in the two sectors.

Given these considerations, the following equilibrium definitions for closed and open economies of the model are necessary:

Definition 1 *An equilibrium of the closed economy is given by a sequence of prices* $\{w_t, r_{kt}, r_{lt}, q_t\}$ *and allocations for firms* $\{k_{at}, n_{at}\}$ *and* $\{k_{mt}, n_{mt}\}$ *and the household* $\{c_{mt}, c_{at}, s_{t+1}\}$ *such that:*

1. The sequence $\{c_{mt}, c_{at}, s_{t+1}\}$ maximizes (1) subject to (2) given prices.
2. $\{k^*_{at}, n^*_{at}\}$ solves (3), given prices, in every period.
3. $\{k^*_{mt}, n^*_{mt}\}$ solves (4), given prices, in every period.
4. Markets clear:

$$s_{t+1} = k_{t+1} + q_t$$

$$1 + r_{t+1} = \frac{r_{lt+1} + q_{t+1}}{q_t}$$

$$c_{at} = y_{at} \tag{6}$$

$$c_{mt} + k_{mt+1} + k_{at+1} = y_{mt} + (1 - \delta)(k_{mt} + k_{at}) \tag{7}$$

The open economy assumption implies that the relative price of the agricultural good is determined on international markets, implying that it will be determined exogenously to the model. In this case, we assume that the domestic economy behaves as a small open economy that takes the price $p_t = \bar{p}$ as given, and therefore, any surplus (deficit) in the market for good m (or good a) is absorbed by international trade. In this economy, market equilibrium conditions ((6) and (7)) do not need to be satisfied in equilibrium any longer. Thus, the firm's problem in the open economy model is maximize the output subject to the inputs allocation. The equilibrium definition for the open economy is given as follows:

Definition 2 *Given the international price* $\bar{p}$*, an equilibrium path for the open economy is given by a sequence of prices* $\{w_t, r_{kt}, r_{lt}, q_t\}$ *and allocations for firms* $\{k_{mt}, n_{mt}\}$ *and the household* $\{c_{mt}, c_{at}, s_{t+1}\}$ *such that:*

1. The sequence $\{c_{mt}, c_{at}, s_{t+1}\}$ maximizes (1) subject to (2) given prices.

2. $\{k_{at}^*, k_m^*, n_{at}^*, n_m^*\}$ is a solution to the following maximization problem:

$$\max_{k_{at},n_{at}} p_t z_{at} k_{at}^{\mu} n_{at}^{\phi} + z_{mt} k_{mt}^{\alpha} n_{mt}^{1-\alpha}$$

subject to

$$\frac{n_{mt}}{n_{at}} = \frac{1-\alpha}{\alpha}\frac{\mu}{\phi}\frac{k_{mt}}{k_{at}}$$

$$n_{mt} + n_{at} = 1$$

3. The aggregate capital and the price of land are given by the following laws of motion:

$$s_{t+1} = k_{t+1} + q_t$$

$$1 + r_{t+1} = \frac{r_{lt+1} + q_{t+1}}{q_t}$$

4 Calibration

In this section, we calibrate the main parameters of our economy in accordance with the values estimated in the literature and certain targets in the data. We will follow the standard approach in the literature on structural transformation in China and employ estimated values obtained from the literature for both the share of factors in the output of the Chinese economy and the parameters of the utility function. Furthermore, we use the same procedure in the case of the parameters that are calculated to match a given target in the data. The main parameters values were selected as follows:

The total factor productivity in the nonfarm sector in the first period of the simulation, z_{m_1}, was normalized at unity. TFP in the agricultural sector in the first period of the simulation, z_{a_1}, and $\bar{c}_a$, the minimum consumption of the agricultural good, were selected to match the employment share of agriculture at the beginning of the simulation. We obtained a value of 0.53 for the former and 0.50 for the latter.

The parameters μ and ϕ and are, respectively, the factor shares of capital and labor in the agricultural sector. We observe values for ϕ in the literature ranging from 0.38 and 0.76, and we obtained 0.50 based on estimates in Brandt and Zhu (2010). For the capital share in the agricultural sector, we selected 0.20, which is similar to estimates obtained by Birchenall and Cao (2013) and Chow (1993) and higher than the 0.12 found by Dekle and Vandenbroucke (2011). The depreciation rate δ is 0.05, while the value of β is 0.97. Those are values commonly used in the literature.

For the factor shares in the nonagricultural sector, α is equal to 0.50, the same value for the labor share in the sector. This value is in line with many estimates found in the literature, which indicates a value close to 0.54. We choose $\gamma = 0.85$ such that, in the long run, the share of employment in the nonagricultural sector is 85%.

In addition to the selection of values for the structural parameters, we need to calibrate a value for the initial capital stock (k_1) of the economy. As our model is calibrated to match the share of workers in agriculture in the initial period of the simulation, using equation (5) and the initial capital stock, we are able to find the ratios of capital per worker in the two sectors of the economy. The value of k_1 is selected such that the capital output ratio was equal to 1.62 (Brandt and Zhu, 2010), as observed in the data.

Table 1: Estimates of the structural parameters

Parameter	Value	Target
β	0.97	Based on literature
$\bar{c}_a$	0.50	Share of employment in agriculture in 1980
γ	0.85	Long run share of employment in the nonfarm sector
α	0.50	Share of capital in the nonagricultural sector
μ	0.20	Share of capital in the agricultural sector
ϕ	0.50	Share of labor in the agricultural sector
δ	0.05	Depreciation rate
z_{m1}	1.0	Normalized
z_{a1}	0.53	Share of employment in agriculture in 1980
γ_a	6.2%	Growth of TFP in the agricultural sector
γ_m	2.5%	Growth of TFP in the nonagricultural sector

While the divergence of the estimates of the structural parameters of the standard model of the structural transformation for the Chinese economy are not significant, with the range of the estimates from other articles suggesting low dispersion of these values, the estimated values for TFP growth in the farm and nonfarm sectors exhibit high dispersion.

A problem that arises in the estimation of these rates results from the incorporation of human capital in the production function of each sector of the economy. Because it is characterized by a lower level of education than the nonagricultural sector, estimated TFP growth in the agricultural sector tends to be underestimated, as by not incorporating human capital in the production function, we implicitly assume that output in the agricultural sector is generated with an educational distribution identical to that in the nonfarm sector. Vast improvements in access to education has occurred in recent years, and these improvements were likely more beneficial to the production of nonfarm goods, the production of which is more educationally intensive relative to the agricultural good. In this sense, failing to consider this effect will lead us to underestimate TFP growth in the agricultural sector relative to the nonagricultural one.

For example, Young (2003) estimated a TFP growth of 1.4% in the nonagricultural sector for the period from 1978 to 1998 by incorporating human capital in the production function of this sector. Following the same methodology as Young (2003), Birchenall and Cao (2013) estimated that TFP growth in agriculture was 6.5% for the period from 1978 to 2007. The values for the TFP growth in each sector suggested by the literature range from 3.7% to 6.5% in agriculture and 1.4% to 4.6% for the non-agricultural sector. We selected a TFP growth rate in the agricultural sector of 6.2% and one of 2.5% in the nonagricultural sector, values compatible with the more recent articles that incorporate human capital in the production functions of both sectors.

As we will show below, the TFP growth values in each sector do not significantly change the qualitative results of our analysis, assuming that the TFP growth in the agricultural sector is higher than in nonagricultural sector, as is the case for the vast majority of articles in this literature. The different growth rates of TFP change the extent to which our calibrated model adheres to the data. However, if we assume a TFP growth rate in the nonagricultural sector higher than that in the agricultural sector, the qualitative results would change significantly.

5 Results

The economy is simulated for 25 periods to capture the main features of the Chinese economy between 1980 and 2005. We define 1985 as the first period of the open economy; hence the simulations between 1980 and 1985 are made in the closed economy, and from 1985 to 2005, we simulate the model for both open and closed economies and compare the results.

In the simulations with an open economy, we need to define the level of the relative price of the agricultural good that was observed during the period from 1985 to 2005. We start noting that there is a relative stability - which can be observed comparing the behavior of the deflators in the rural and urban areas, for instance - of the relative price between agricultural and nonagricultural goods during this period. Data does not indicate any clear upward or downward trend.

It is important to emphasize this point. In our model, the elasticity of substitution between agricultural and nonagricultural goods is less than 1, implying that an increase in the demand for the agricultural good is smaller than the increase in its supply, leading to a decline in the relative price of the agricultural good in the closed economy. This decline in relative prices increases the speed at which labor is reallocated from agriculture to the nonfarm sector, making the transfer of labor across sectors faster than that observed in the data. In the case of the open economy, taking into account the fact that the relative price of the agricultural good has remained relatively stable over the period, the transfer of labor occurs at a slower pace than in the case of the closed economy and is consistent with what is observed in the data.

From 1980 to 1984, the model is simulated for the closed economy only; and for both economies from 1985 onwards. This procedure is due to the fact that relative price data is only available after 1985. Given that we know that relative price was relatively stable after 1985, we set the price of the open economy in 1984 equal to that of the closed economy and kept it constant after this.

As we can see from the figure below, the path for the relative price of agricultural good in the open economy more accurately replicates the values observed in the data over the simulated period. As noted above, the closed economy model implies a decline in the relative price of the agricultural good in this period and a faster reduction in the share of workers in the agricultural sector compared to the open economy model.

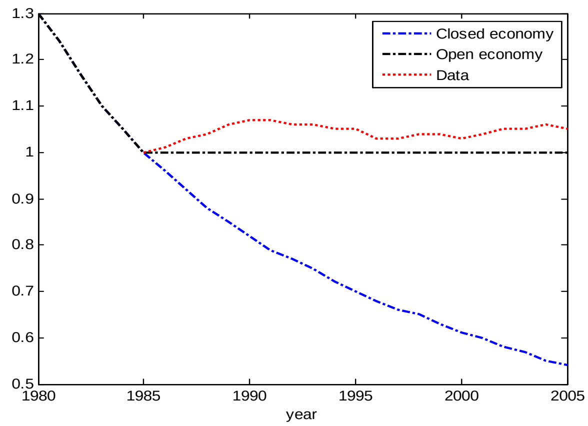

Figure 6: Relative price of agricultural good

The open economy model is able to replicate the path of the labor share in agriculture from 1980 to 2005. The figure below demonstrates that the reallocation of labor between the agricultural and nonagricultural sectors occurs more slowly in the open economy, suggesting a greater role for trade than what is usually credited in the literature. The model simulations for the open economy yield a decline in the share of employees in agriculture similar to the level observed in the data (0.24pp).

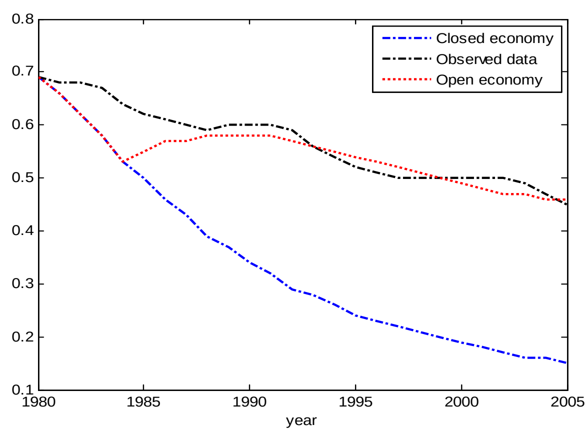

Figure 7: Employment share in agriculture

In the simulations using the closed economy, the reallocation of labor from the agricultural sector to the nonagricultural sector occurs more rapidly than what is observed in the data, meaning that the share of workers employed in agriculture in 2005 is much lower than what was actually observed in the data (15% versus 45%). Note that the speed of labor reallocation from one sector to the other depends on, among other factors, total factor productivity growth rates in each sector. The higher the TFP growth in the agricultural sector relative to that in the nonagricultural sector, the faster will be this shift. This is important due to the large disparity between the TFP growth rates estimated for each sector of the Chinese economy. However, assuming that TFP growth in agriculture is more rapid than the TFP growth in the nonagricultural sector, as it is the case for the majority of the articles in the literature, the qualitative results of the model remain unchanged, as the transfer rate of workers from the agricultural sector to the nonagricultural sector is larger in the closed economy.

For example, the figure below depicts the results of our open economy model for the case in which the TFP growth rates in the agricultural and non-agricultural sectors are 6.2% and 3.2%, respectively, as in Brandt and Zhu (2010). Moreover, we depict the case where TFP growth in agriculture (3.7%) is lower than in the nonagricultural sector (8.8%[3]), as in Dekle and Vandenbroucke (2011). In this case, the model would better conform to the data in the closed economy, as the reallocation of labor from agriculture to the nonfarm sector occurs faster in the open economy. This result is explained by the fact that, in the open economy, the problem of selecting the share of workers employed in agriculture that maximizes the total output of the economy would lead to an outcome of less production in the more inefficient sector. This is another indication, given the observed growth of trade in China, that TFP growth in agriculture was higher than in the rest of the economy.

[3] In this case, we consider the TFP growth rate in the nonagricultural private sector. As noted in many articles in the literature on China's structural transformation, the TFP growth rate in the nonagricultural state sector is much lower than the TFP growth rate in the nonagricultural private sector. By failing to consider this fact, our estimates of the growth rate in the nonagricultural sector are upward biased.

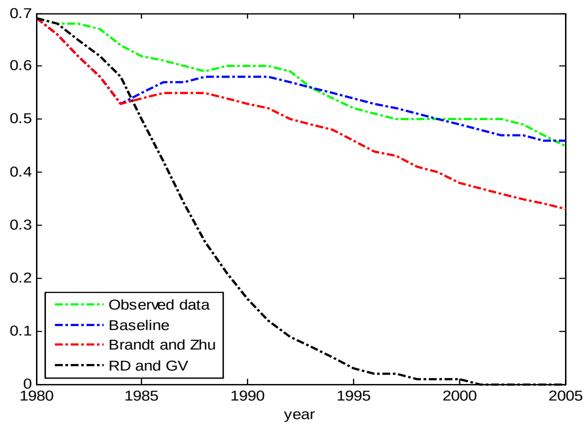

Figure 8: Employment in Agriculture (% of total employment)

The model can also capture other facts observed during the Chinese economy's period of strong growth reasonably well. An important aspect mentioned above is the trade path. In the figure below, we depict the dynamic of the total flow of trade (imports plus exports as a percentage of GDP) predicted by the model and the values observed in the data. The model is able to replicate the initial trend of the trade path in the Chinese economy reasonably well, but it does not replicate the upward trend observed in recent years. Another important aspect to note is the behavior of savings as a percentage of GDP predicted by the model. We can see from the right hand figure that the closed economy model underestimates the path of savings throughout the period, especially in recent years, in which there was an increase in this measure. The open economy model tends to overestimate the behavior of the saving rate in the most recent period, which explains the relative stability of total trade to GDP ratio in the period.

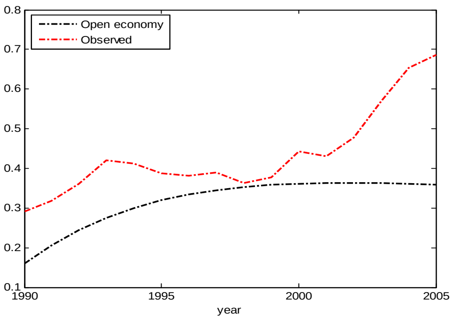

Figure 9: Total trade as % of GDP

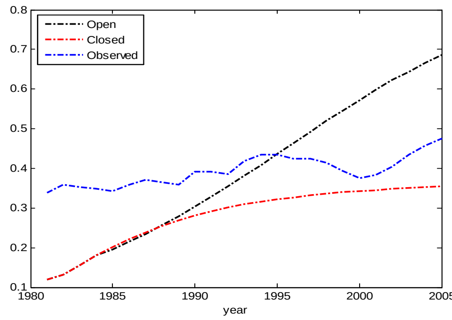

Figure 10: Savings as percentage of GDP

The model is able to replicate many other facts observed in the Chinese economy over the period 1980-2005, for example, the significant growth rates of the capital stock, output growth in the agricultural and nonagricultural sectors and the reallocation of labor from agriculture to the nonagricultural sector. As mentioned above, although the model does not replicate the current magnitude of international trade in China, it is able to replicate the trend towards increased trade flows during the period considered in the simulation.

Table 2: Model results[4]

		Baseline calibration	
	Data	Closed economy	Open economy
$n_{a,1980}$	0.69	0.69	0.69
$n_{a,2005}$	0.45	0.15	0.46
TB_{2005}	0.69	–	0.36
gy	0.09	0.07	0.09
gy_a	0.07	0.03	0.07
gy_m	0.11	0.10	0.11
gk	0.10	0.09	0.12

6 Counterfactual

In this section, we conduct simulations with our calibrated economy to estimate the agricultural sector's contribution and the contribution from trade to the recent

[4] TB is total trade as a percentage of GDP, n_a is the employment share in agriculture, gy is the output growth, and gk is the growth rate of capital stock.

performance of the Chinese economy. As noted above, the growth trajectory of the Chinese economy in the case of the open economy model is closer to that observed in the data than in the case of the closed economy. Thus, the first question that arises is what is the contribution of trade to China's development process. The figures below compare the path of the observed output with the trajectories of product in the open and closed economy cases. The open economy model explains 100% of the output trajectory of the Chinese economy while the closed economy explains only 74%. Because the models differ only by the insertion of the Chinese economy in international trade, this result suggests that international trade explains 26% of the path of the product of the Chinese economy in the period.

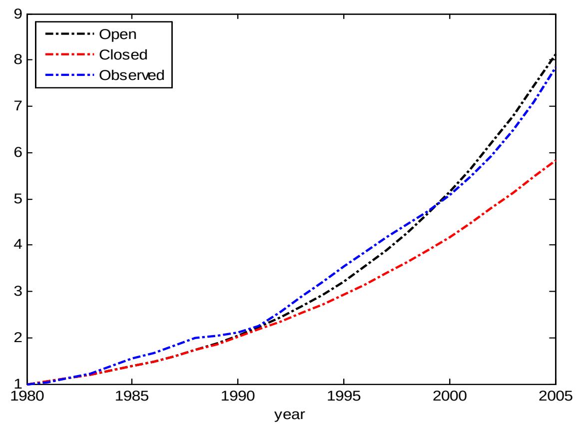

Figure 11: Output path in the Chinese economy

To calculate the contribution of the agricultural sector for the development of Chinese economy, we simulate our model for the case in which TFP growth in the agricultural sector is equal to zero and for the case in which TFP in the nonagricultural sector is equal to 6.2%, the TFP growth in the agricultural sector. The simulations reflect the most extreme cases for the paths of TFP in each sector. In the first case, the TFP in agriculture remains stagnant and, in the second, the growth rate of TFP in the nonagricultural sector is the same as in the agricultural sector and therefore much higher than what was observed in the data.

As seen from the figures below, the results of the first experiment demonstrate that the share of workers in agriculture would have declined much more rapidly than observed in the data. One should also note that in the initial periods of the simulation, the share of workers in agriculture is higher than that in our baseline scenario. This follows from the fact that in the early periods of our simulations, the economy remains closed, which implies a slower reallocation of workers across sectors in scenarios in which the TFP growth rate in agriculture is lower.

Despite the lower TFP growth in the agricultural sector relative to the baseline scenario, the share of workers reallocated from agriculture to the nonagricultural sector is much higher, increasing the share of workers employed in the sector with the highest labor productivity. Thus, the lower productivity growth in the agricultural sector is partially offset by the productivity gains achieved by the transfer of labor to the sector with higher labor productivity. This means that although the aggregate output of the economy grows at a lower rate than that observed in the baseline scenario, it continues to exhibit a strong growth path throughout the period.

Note that this result differs from what would occur in the case of a closed economy, as the low TFP growth in the agricultural sector would cause significant part of the workforce to remain in the low productivity sector, and therefore there would be no compensation for the reallocation of labor from agriculture to the nonfarm sector. This difference between the closed and open economy results can be observed from the difference in the paths of relative output (relative to baseline) in the Chinese economy in the right-hand figure below. In the case of an open economy, the more rapid reallocation of labor from agriculture to the nonagricultural sector would result in a decline in production lower than that observed in the case with a closed economy.

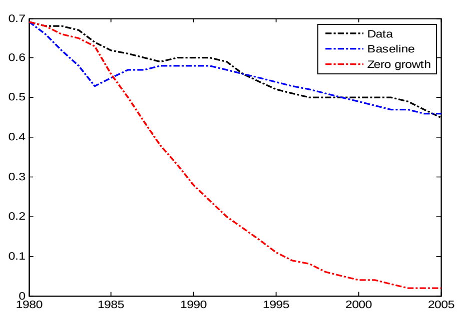

Figure 12: Employment share in Agriculture

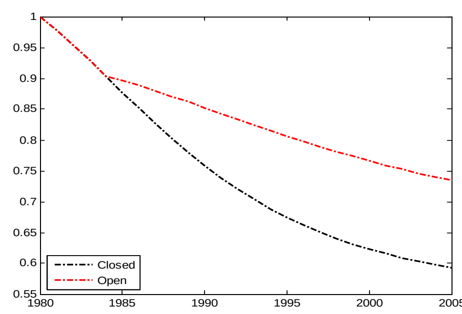

Figure 13: Relative output (in relation to basecase)

As expected due to the structure of the external sector in the model, low productivity growth in agriculture would cause the Chinese economy to specialize in producing the nonagricultural good that possesses the greatest comparative advantage. Thus, the model would predict that the Chinese economy would exhibit a large trade surplus in the nonagricultural sector and a large trade deficit in the farm sector. This mechanism, which is not present in the closed economy, would further increase the aggregate output of the economy, partially offsetting lower output growth in agriculture.

When we set TFP growth in the agricultural sector equal to zero, Chinese production in 2005 would have been 73% of that predicted by the baseline scenario for the open economy. In the case of the closed economy, maintaining a larger share of workers in the agricultural sector would contribute to a substantially reduced total output growth. In this case, the experimental results indicate that total output would be just 59% of the baseline closed economy. Therefore, the open economy model suggests that, despite that the strong growth of TFP in agriculture was an important determinant of the growth path of the Chinese economy during the reform period, other factors such as rapid capital accumulation and strong growth in international trade also played an important role. Therefore, the exercise shows that the agricultural sector explained 27% of the path of the output of the Chinese economy in the open economy model.

In the second counterfactual, in which we consider the growth rate of TFP in the non-agricultural sector similar to the growth rate of TFP in the agricultural sector, the dynamic of labor reallocation across sectors in the closed economy is similar to the one exhibited by the open economy. In both cases, the decline in the share of workers in agriculture occurs very quickly. In the case of the open economy that reduction stems from the fact that an increase in income spurred by strong growth in TFP in each sector reduces the relative demand for the agricultural good, leading to a rapid decline of its price and therefore a transfer of labor from the agriculture to the nonagricultural sector. In the open economy, the mechanism is similar to that seen in the previous counterfactual, in which the economy specializes in the sector with higher labor productivity.

The results of this experiment are shown in the figures below. The reduction in the share of employed in agriculture occurs more rapidly in the open economy, which implies a higher output growth in this case. Considering the ratio between the output in the closed and in the open economy predicted by both counterfactuals, this measure decreases in both cases, which points to an underestimation of the output in the closed economy.

In the first counterfactual, in which we consider a zero growth rate for TFP in the agricultural sector, the final product in the closed economy is 58% of the output of the open economy. In the counterfactual in which TFP in the nonagricultural sector grows at the same rate that in the agricultural sector, the output in the closed economy is 93% of the GDP in the open economy.

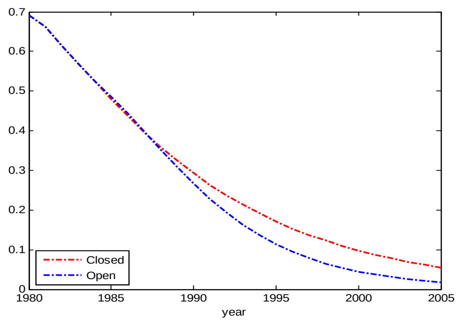

Figure 14: Employment share in agriculture - equal TFP growth rates

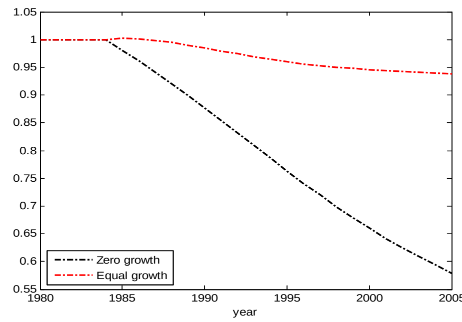

Figure 15: Relative output between closed and open economies

7 Conclusion

Our paper reviewed the recent experience of the Chinese economy from the perspective of a model of structural transformation and trade liberalization. As highlighted in previous sections, the observation that the relative price between agricultural and nonagricultural goods remained relatively stable during China's reform period implies that the predictions of a theoretical model of structural transformation using a closed economy to determine the relative price of the agricultural good is not compatible with the observed data.

In this sense, a closed economy model would tend to estimate a reallocation of workers from agriculture to the nonagricultural sector that is more rapid than observed in the data. By considering an open economy framework, our model is able to more accurately replicate the trend in the share of workers in each sector of the Chinese economy for the period from 1980 to 2005.

The first conclusion of our article is that international trade explained 26% of the path of per capita GDP in China in the post-reform period. This result stems from the fact that the open economy model explains 100% of the growth path in China while the closed economy model explains only 74% of this trajectory.

Another important source of growth was the significant growth of total factor productivity in the agricultural sector. The counterfactual exercise using our calibrated model demonstrated that even if we assume 0.0% TFP growth in the agricultural sector, output in China would have been 73% of that observed in the period considered, which points to a contribution of 27% of the agricultural sector for Chinese economic development. This is because, in our model, this scenario of zero TFP growth in the agricultural sector would imply a greater reallocation of labor to the nonagricultural sector, a result that is the opposite of what would occur in a closed economy model. This shift occurs because, in an open economy framework, where the central planner selects the share of workers in each sector of the economy to maximize total output, the share of workers in the more inefficient sector would decline more rapidly. Other factors such as rapid capital accumulation also played an important role in explaining the strong growth of the Chinese economy.

In this sense, a framework that incorporates international trade reveals an additional important force behind the impressive growth of the Chinese economy in this period, which is not captured by traditional models that consider a closed economy framework.

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