A Quantitative Analysis of China's Structural Transformation*

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Abstract

The structural transformation of China–or the reallocation of resources from the agricultural sector to the nonagricultural sector–between 1978 and 2003 was truly remarkable. We develop a two-sector neoclassical growth model to quantitatively assess the driving forces of China's recent structural transformation. In addition to the forces currently emphasized in the literature–sectoral productivity growth–we show that China's transformation was accelerated significantly by the gradual reduction in the relative size of the Chinese government. *Keywords: Chinese Economy, Structural Transformation, Neoclassical Growth Model.*

1 Introduction

Between 1978 and 2003, the Chinese economy experienced a real annual rate of total GDP growth of 8.4 percent, a performance that makes China the most rapidly growing economy in the world during this period. Labor productivity grew during this period at a remarkable 5.7 percent per year. At the same time

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the Chinese economy experienced what is often labelled a "structural transformation:" resources were reallocated away from the agricultural sector and into nonagriculutural activities. There exists a growing literature analyzing similar episodes in various countries and time periods, and our paper contributes to this literature.[1] We develop a model to quantitatively assess the driving forces of China's recent structural transformation. We argue that, in addition to the forces currently emphasized in the literature, namely sectoral productivity growth, the Chinese transformation was also accelerated, to a significant degree, by the gradual reduction in the size of the Chinese government between 1978 and 2003.

Our focus is on the trends in the employment and output shares of agriculture during the period 1978-2003. These trends are depicted in Figure 1 and 2. Particularly noteworthy is the decline in the relative share of agricultural employment from 70 percent of all workers in 1978 to less than 50 percent of all workers in 2003. The share of workers in private industry has increased from a negligible level in the mid-1980s to approach about 25 percent of all workers by 2003. The share of workers in public industry, while increasing until the mid-1990s, declined since the late 1990s, as State enterprises and Township and Village enterprises (TVEs) were privatized. Figure 2 depicts the employment and output of agriculture divided by the employment and output in the total private sector. Note that, while agricultural output was 94 percent of total private output in 1978, it represented only 22 percent of total private output by 2003.[2]

We measure the contributions of three key exogenous driving forces in China's structural transformation. Productivity growth in agriculture and nonagriculture constitute two of these forces, and in considering them we relate to the already existing literature on structural transformations such as Ngai and Pissarides (2007) and Rogerson (2008).[3] Briefly, in our model set-up, increases in productivity growth in both the agricutural and nonagricultural sectors induce a decline in agriculture's share of employment and output. Specifically, we build a

[1] See for example Ngai and Pissarides (2007), Kongsamut, Rebelo, and Xie (2001), and Rogerson (2008). On the structural transformation of China in particular, see Brandt, Hsieh, and Zhu (2005), and Song, Storesletten, and Zilbotti (2008).

[2] Total private output is the sum of agricultural output and private nonagricultural output.

[3] Recent papers on structural transformations tend to be divided into two types: those that base structural transformations on sectoral differences in productivity growth (Ngai and Pissarides, 2007), and those that base structural transformations on sectoral differences in income demand elasticities (Kongsamut, Rebelo, and Xie, 2001). There are also models combining both types of models (Rogerson, 2008).

model where the income elasticity of agricultural goods is less than one so that, as income increases, resources are shifted away from agriculture and into the nonagricultural sector. Increases in productivity in both the agricultural and nonagricultural sectors raise income, and lower the relative demand for agricultural goods, resulting in a flow of labor from agriculture into nonagriculture.

In the case of the Chinese economy, however, we should consider another potential driving force: the reduction in the size of the Chinese government which took place during the period we analyze. Figure 3 shows the reduction in the government's share of total output. We conjecture that reduced government intervention affected the allocation of resources across sectors in China through an income effect. As the relative size of the Chinese public sector shrank, inefficiencies were reduced and income rose, thus, reducing the relative size of agriculture, given the less than unitary income elasticity of agricultural goods. Thus, each of the three driving variables we consider act towards reallocating resources away from agriculture.

This paper is organized as follows. In the next Section, we briefly describe the Chinese aggregate statistics, relegating a more complete description to the Data Appendix. For our purpose, it is particularly important to distinguish between the private and public sectors. We explain our classification and perform a growth accounting exercise to measure Total Factor Productivity (TFP) in the private agricultural and nonagricultural sectors– two of our driving forces. We show that while TFP growth in agriculture was much higher than in nonagriculture overall, as in Young (2003), this comparison masks the large discrepancy in TFP growth rates between the private and public nonagricultural sectors. We show that between 1978 and 2003, average TFP growth rates in the public and private nonagricultural sectors were 0.5 percent and 6.9 percent, respectively.

In Section 3, we develop our model economy. Our model is a two-sector version of the optimal growth model with two goods, non-homothetic preferences and a government. The non-homotheticity is due to a subsistence level of agricultural consumption, which results in a less-than-unitary elasticity of agricultural consumption to income. This feature of the model is the source of the income effect shifting resources away from agriculture as income rises. We model the Chinese government through an exogenous sequence of proportional income tax and employment. We assume that the fiscal revenue is redistributed to households through a lump-sum transfer.

In Section 4, we perform our quantitative analysis. Our exercise consists, first, in constructing a baseline calibration where the key parameters are chosen

so that our model exhibits the same output and employment shares of agriculture as in the Chinese economy in 1978. In this baseline calibration we let the sectoral productivity variables grow at rates determined by the growth accounting exercise of Section 2, and we let the size of the Chinese government be given by the data displayed in Figure 3. Armed with our baseline calibration, we proceed to compute a set of experiments where the only difference with our baseline calculation is that we let, one at a time, one of the three driving forces deviate from its baseline trend throughout the entire 1978-2003 period. We interpret the discrepancies between our baseline results and our counterfactuals as measuring the contribution of the particular driving variable in explaining China's structural transformation.

2 Data

All data cited in this Section, unless otherwise noted, are from the annual issues of the *Chinese Statistical Yearbook (CSY)*, issued by the State Statistical Bureau (SSB).[4] Views among Chinese economy specialists differ as to the reliability of Chinese official economic statistics. Young (2003) and Rawski (2004) argue that GDP (output) growth is systematically overstated by the official statistics, while investment is understated. Chow (1993) and Holtz (2006) on the other hand, argue that Chinese official statistics are on the whole reliable. It is beyond the scope of this paper to judge these arguments regarding the accuracy of Chinese official statistics. In general, we accept the Chinese official statistics, making adjustments only in cases when the deficiencies of the commonly used measures (such as in GDP and in investment) are well known.

As mentioned earlier, the main challenge for our purpose is to classify the Chinese data into our three sectors of interest: the agricultural sector, the nonagricultural public sector, and the nonagricultural private sector.

The agricultural sector is defined as the primary industry, which includes forestry, livestock, and fishing. Liberalization of the Chinese agricultural sector started from the introduction of the household responsibility system in 1981,

[4] Our data mainly come from the CSY of 2005, so that our data do not include the revisions to GDP data included in the CSY of 2006. The CSY of 2006 significantly raised the nominal value of tertiary (service) sector output starting in 1998, so that nominal service sector output in 2004 was close to 50 percent higher in the CSY of 2006, compared to the CSY of 2005 (Holtz, 2006). This has resulted in Chinese aggregate nominal GDP being 10 to 17 percent higher between 1999 and 2004. However, curiously, the GDP deflators were raised along with the nominal GDPS, so that real GDP growth rates have not appreciably changed in the CSY of 2006, compared to the CSY of 2005.

in which farmers could sell at market prices agricultural products produced above quota. While acknowledging that the Chinese agricultural sector was not completely liberalized in the early 1980s, we assume in our model that the agricultural sector was market driven by this time, since liberalization in this sector proceeded much faster than in the nonagricultural sector.

The nonagricultural sector is defined as the sum of the secondary and tertiary industries. In the nonagricultural public sector, we include State-owned enterprises, Collective and Cooperative units, and Township and Village enterprises (TVEs). The nonagricultural private sector includes all other types of firms, including Private enterprises, Self-employed workers, and firms with foreign investment.[5] We note that at the beginning of the reform period in 1978, the public sector produced nearly all of nonagricultural output. Even in 1990, public sector output was over 90 percent of nonagricultural output.

Table 1 summarizes our accounting of Chinese economic growth from 1978 to 2003. We show in the Appendix that the capital share is 0.12 for agriculture, and 0.54 for nonagriculture; the labor share is 0.76 for agriculture, and 0.46 for nonagriculture; and the land share is 0.12 for agriculture. Using these factor shares we can compute a measure of total factor productivity (TFP) growth by sector. Note that our measure of TFP overstates the importance of productivity per se, since it also captures the rise in productivity owing to human capital accumulation. Nonetheless, this is the measure that is consistent with the model we develop in Section 3. Figure 4 represent our series for sectoral TFP, normalized to unity in 1978.

We find an annual growth rate of TFP of 4.4 percent in agriculture versus 6.9 percent in the private nonagricultural sector. We also find little to no pro-

[5] Unlike in capitalist economies, in China, there are conceptual difficulties in classifying firms into the public and private sectors. In particular, Township and Village enterprises—the largest employer in China since the early 1990s (about 135 million workers)–are owned and operated by local governments. Much has been made about how these TVEs owned by local governments actually operate like private corporations. Although China's local governments may try to operate a miniature state-run economy, ultimately each local producer is subjected to competition from thousands of other villages. In this competitive environment, each local government faces a relatively hard budget constraint; and has to make its own enterprise economically successful (Naughton, 2007, Ch. 12). On the other hand, local governments do serve as guarantors of TVE borrowing. If that is the case, then capital allocation decisions by TVEs are not determined entirely by the market. In fact, continued government interference, and corruption are described as disadvantages of local government ownership. These disadvantages of local government ownership seem to have worsened since the mid-1990s, as employment and profitability in the TVEs have declined (Naughton, 2007, Ch. 12). While acknowledging that the TVEs may be subject to some market forces, we classify TVEs as belonging to the public sector, since ultimately, the (local) government decides how much labor and capital that these firms employ.

ductivity growth in the public sector. This finding of negative or very small productivity growth in Chinese state industries is consistent with Jefferson, Rawski, and Zheng (1989), and the OECD (2005). In particular, the OECD (2005) uses a large scale firm level survey conducted by the Chinese government, and finds that from 1998 to 2003 private sector firms had TFP growth rates between 121 percent and 46 percent higher than firms with varying degrees of state control. As expected and consistent with the OECD's (2005) firm level findings, TFP growth rates in Chinese private nonagricultural industries are very high.

3 Model

3.1 Environment

Time is discrete and indexed by $t = 0, \ldots, \infty$. There is a single infinitely-lived representative household endowed with 1 unit of productive time per period. Its preferences are defined over two goods: an agricultural good called a and a nonagricultural (manufacturing and service) good called m. The latter is the numéraire. The price of good a is denoted by p_t. It is produced by the agricultural sector with the services of labor, capital and land. The stock of productive land, l, is fixed to one and owned by the household. (In the data, the agricultural land area is virtually fixed, increasing by a total of less than 1.5 percent in 25 years.) The nonagricultural good is produced with capital and labor. Physical capital depreciates at rate δ and the interest rate between period $t-1$ and t is denoted by r_t. The rental rate of capital is then $r_t + \delta$. Land does not depreciate. Its price during period t is denoted by q_t and its rental rate between period $t-1$ and t by i_t. The real wage rate during period t is denoted by w_t. Good a is used for consumption only, while good m is used for consumption and for capital accumulation.

There is a government characterized by an exogenous sequence of employment, $\{h_{gt}\}$, and proportional income tax, $\{\tau_t\}$. The tax revenue is redistributed via a lump sum transfer, T_t. We interpret public employment as a tax: Each period, a household must allocate h_{gt} units of time to governmental work, while the remaining $1 - h_{gt}$ units of time are allocated optimally between the two sectors.

In modelling the public side of the Chinese economy we must take into account the fact that, at times, it accounted for more than 50 percent of all economic activity. In other words, the income distributed by the government,

as a result of its various activities, was larger than private income. Our model is consistent with this feature of the data when we interpret transfers as income distributed as a result of government production and, therefore, subject them to the proportional income tax.

3.2 The Household

The preferences of the representative household are described by

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

where c_{mt} and c_{at} are consumption flows of good m and a, respectively. $\beta \in (0,1)$ is the subjective discount factor and $\bar{c}_a > 0$ is a constant parameter which can be interpreted as a "subsistence" level of consumption of the agricultural good. In each period, the household's budget constraint is:

$$c_{mt} + p_t c_{at} + s_{t+1} = \left[w_t\left(1 - h_{gt}\right) + \left(1 + r_t\right) s_t + T_t\right]\left(1 - \tau_t\right) \text{ all } t. \tag{2}$$

Household's saving during period t is denoted by s_{t+1}. The term T_t is a transfer received from the government. Note that the wage rate, w_t, is paid for hours worked outside of the public sector, and that we assume that this rate is not sector-specific. Payments for hours worked in the public sector are subsumed in the transfer T_t. This feature captures the notion that the government need not pay the market wage to its employees. Note that transfers received from the government are taxed as a source of income. We choose this specification in line with our interpretation that government transfers represent income distributed from the public provision of certain goods and services. More importantly, though, this specification allows us, in the quantitative part of our analysis, to use data on the size of the Chinese government to calibrate the tax rate τ_t.

From the first order conditions of the household, one finds

$$\frac{c_{m,t+1}}{c_{mt}} = \beta\left(1 + r_{t+1}\right)\left(1 - \tau_{t+1}\right)$$

which shows how the proportional income tax affects the growth rate of consumption of the nonagricultural good. A reduction in the tax rate yields, everything else equal, a higher growth rate for nonagricultural consumption and labor demand in the non-agricultural sector.

3.3 Government

We assume that the government runs a balanced budget at each date. Thus, the government's revenue or output at date t is entirely redistributed via T_t. Hence, the government's budget is

$$T_t = \left[w_t \left(1 - h_{gt}\right) + \left(1 + r_t\right) s_t + T_t\right] \tau_t \tag{3}$$

or

$$T_t = \frac{\tau_t}{1 - \tau_t} \left[w_t \left(1 - h_{gt}\right) + \left(1 + r_t\right) s_t\right].$$

Note, for later reference, that the first of these equations indicates how the tax rate $\{\tau_t\}$ can be measured from the ratio of public-to-total output. Note also, from the second equation, that transfers, can be larger than private output. This, again, is in line with our interpretation of government revenue or transfers as public output. Indeed, the size of the Chinese government (that is public output) during the earlier years of our period of investigation was much larger than that of the private sector.[6]

3.4 The Firms

In the private nonagricultural sector, the technology is given by

$$y_{mt} = F_m\left(k_{mt}, h_{mt}\right) = z_{mt} k_{mt}^{\alpha} h_{mt}^{1-\alpha}, \ \alpha \in (0, 1)$$

In the agricultural sector it is

$$y_{at} = F_a\left(k_{at}, h_{at}\right) = z_{at} k_{at}^{\mu} h_{at}^{\phi}, \ \mu, \phi \in (0, 1), \ \mu + \phi \in (0, 1).$$

The variables h_{jt} and k_{jt} $(j = a, m)$ represent employment in sector j and the capital stock, respectively. Note that the stock of land is normalized to 1. The nonagricultural sector solves

$$\max\left\{F_m\left(k_{mt}, h_{mt}\right) - w_t h_{mt} - \left(r_t + \delta\right) k_{mt}\right\} \tag{4}$$

[6] One interpretation of this budget constraint is as follows. Let private income at the beginning of period t be denoted by $x_t = w_t\left(1 - h_{gt}\right) + \left(1 + r_t\right) s_t$. It is taxed at the rate τ_t, giving rise to a transfer $\tilde{T}_{1t} = \tau_t x_t$. This transfer itself is taxed as income, giving rise to a second transfer whithin the same period, $\tilde{T}_{2t} = \tau_t \tilde{T}_{1t} = \tau_t^2 x_t$, and so on... The sum of all transfers distributed during this period is then $T_t = \sum_i \tilde{T}_{it} = x_t \tau_t / \left(1 - \tau_t\right)$.

and the agricultural sector solves:

$$\max \left\{ p_t F_a \left(k_{at}, h_{at} \right) - w_t h_{at} - \left(r_t + \delta \right) k_{at} - i_t \right\}. \tag{5}$$

The stock of private capital, k_t, is $k_t = k_{at} + k_{mt}$. Note that total factor productivity, z_{jt}, can differ across sectors both in levels and in rates of growth. These variables constitute two of the four exogenous driving forces in the model economy.

3.5 Equilibrium

In equilibrium several markets must clear: labor, savings and goods and services. The labor market clearing condition is

$$h_{mt} + h_{at} = 1 - h_{gt}$$

where the left-hand side is labor demand and the right-hand side is the supply of labor by households. The savings market clearing condition is

$$s_{t+1} = k_{a,t+1} + k_{m,t+1} + q_t.$$

Where the left-hand side represents a household's total saving at time t. Savings are allocated between three assets: capital in the agricultural sector, capital in the non-agricultural sector and land. The stock of land is 1 so, in equilibrium, the representative household must own a total of one unit of land at the beginning of each period. The price of land during period t is denoted by q_t, hence the last term in the right-hand side. Note that the presence of three assets implies that an arbitrage condition must hold:

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

that is, the gross rate of interest, on the left-hand side, must equal the gross return on land which is represented on the right-hand side. The latter is a function of the price of land and its rental rate. Equations (4) and (5) already include the assumption that the rate of return on physical capital is the same in the two sectors and is given by the rate of interest.

The market clearing condition for the agricultural good is

$$c_{at} = y_{at},$$

and, finally, the resource constraint reads

$$c_{mt} + k_{t+1} = y_{mt} + (1 - \delta) k_t.$$

The Appendix shows the details that lead to this result.

Given a sequence of taxes $\{\tau_t\}$ and public employment $\{h_{gt}\}$, an equilibrium is a sequence of prices $\{w_t, r_r, i_t, p_t, q_t\}$ and allocations for firms $\{k_{mt}, h_{mt}\}$ and $\{k_{at}, h_{at}\}$, and the household $\{c_{mt}, c_{at}\}$ such that

1. The sequence $\{c_{mt}, c_{at}\}$ maximizes (1) subject to (2) given prices;
2. The sequence $\{k_{mt}, h_{mt}\}$ solves (4) given prices, at every period;
3. The sequence $\{k_{at}, h_{at}\}$ solves (5) given prices, at every period;
4. Market clears.

4 Quantitative Analysis

The quantitative exercise is the following. First, we choose a time path for the exogenous driving forces: $\{z_{mt}, z_{at}, \tau_t, h_{gt}\}$. Second, we assign values to some parameters using a priori information. In particular, we assign values to the factor shares in agriculture and nonagriculture based on the data discussed in Section 2. There are three parameters not pinned down by this exercise: the subsistence level of agricultural consumption, $\bar{c}_a$, the initial level of agricultural TFP, z_{a1}, and the intial capital stock in the nonagricultural sector, k_{m1}. We choose these parameters so that in the first period of our model economy, agriculture's share of private output and private employment, and the output to capital ratio in nonagriculture are close, in a least square sense, to their empirical counterparts in 1978. We emphasize that we do not attempt to fit our model to the entire time paths of agricultural employment or to output. Instead, we interpret the gap between the model's predictions for these paths, and their empirical counterparts, as a measure of the quantitative importance of the mechanisms at work in our model economy. We then proceed to simulate the same transition paths under a set of couterfactual alternatives regarding the

driving forces of the model. This exercise allows us the assess what mechanisms are quantitatively the most important in generating our baseline results.

4.1 Calibration

4.1.1 Exgenous Driving Forces

The exogenous forces driving the model economy are total factor productivity in each sector $\{z_{mt}\}$ and $\{z_{at}\}$, the proportional income tax rate, $\{\tau_t\}$, and the public employment rate, $\{h_{gt}\}$. For the paths of $\{z_{mt}\}$ and $\{z_{at}\}$ we use the data presented in Figure 4 from 1978 to 2003. We use the normalization $z_{m1} = 1$ in the nonagricultural sector. We explain below how we determine the initial level of total factor productivity in non-agriculture, z_{a1}. Since agents are forward looking, we need to take a stand on the behavior of z_{at} and z_{mt} beyond 2003. We assume z_{mt} and z_{at} continue to grow at their average growth rates for the period 1978–2003: $g_a = 1.051$ and $g_m = 1.069$.

To calibrate the sequence of tax rates $\{\tau_t\}$ we use the share of public output to total output as shown in Figure 3 and as prescribed by Equation (3). The tax rate calibrated this way decreases from the neighborhood of 75 percent to about 30 percent, implying that the government sector went from being $0.75/(1-0.75) = 3$ times bigger than the private sector in 1978 to being less than half its size in 2003 $(0.3/(1-0.3) = 0.42)$. Again, we need to take a stand on the path of τ_t beyond 2003. In our baseline exercise we assume that it remains constant at 30 percent, i.e., the value that τ_t reaches in the data in 2003. As a socialist economy, China's public output as a proportion of total output is obviously quite high.

We use the actual sequence of public employment for $\{h_{gt}\}$ – see Figure 1. We assume that, past 2003, the share of public employment remains constant at its average level during this period at 28 percent.

4.1.2 Parameters

The factor shares α, μ and ϕ are discussed in Section 2 and in the Data Appendix. We use $\alpha = 0.54$ for the capital share in the nonagricultural sector, and $\mu = 0.12$ and $\phi = 0.76$ for the capital and labor shares in the agricultural sector, respectively. We set $\beta = 1.02/1.07$ and $\delta = 0.05$. This value for β is consistent with a long-run growth rate of 2 percent per year and a rate of return of 7 percent.

Three parameters remain: $\bar{c}_a$, the subsitence level of consumption, z_{a1}, the initial level of agricultural TFP and k_{m1} the initial stock of capital in the nonagricultural sector.[7] We pick them to minimize the distance between the model and the data, in terms of the initial share of agricultural employment and output:

$$\min_{\bar{c}_a, z_{a1}, k_{m1}} \left(\frac{h_{a1}}{h_{a1} + h_{m1}} - 0.98 \right)^2 + \left(\frac{p y_{a1}}{p_1 y_{a1} + y_{m1}} - 0.94 \right)^2 + \left(\frac{k_{m1}}{y_{m1}} - 10.4 \right)^2$$

4.2 Baseline Results

Our baseline calibration is displayed in Table 2. Figures 5 and 6 show the model's prediction for the employment and output shares of agriculture, versus their empirical counterparts. Note again that we compare the size of agriculture to that of the total private sector, which is the sum of agricultural employment (output) and private nonagricultural employment (output). The mechanisms at work in our baseline exercise tend to overpredict the transition of labor out of agriculture and underpredict the shift in output from agriculture to nonagriculture.

The first two lines of Tables 3 and 4 report our quantitative analysis. In the Chinese data, agriculture's share of total private sector employment exhibits a 30 percentage-point drop (from 98 to 68 percent of private labor). Our baseline model predicts a 35 percentage point decline, overpredicting the movement of labor out of agriculture by 16 percent. For output, the Chinese data show a 72 percentage point actual decline in the size of the agricultural sector relative to the output in the total private sector. Our model predicts a 45 percent decline in the agricultural output share, which is only 62 percent of the actual decline in the data.

At this point it is worth taking note of the fact that our model does not match exactly the time path of the employment and output shares of agriculture. This is because first that we calibrated our model to a single point in time, thereby leaving the time paths unconstrained and, second, to the fact that there are forces at work in the actual Chinese economy that we did not model. We suggest that one can still learn from our exercise since adding additional forces to the model does not necessarily imply that our driving forces would play less

[7] The first order conditions of the firm imply that the capital per worker in the agricultural sector is proportional to that of the nonagricultural sector. Thus, choosing k_{m1} and h_{a1} determines the initial stock of capital in the economy, as well as its distribution across sectors.

of a role.

4.3 Counterfactual Experiments

We now proceed to simulate our model economy under a set of alternative assumptions regarding the driving forces. We start by considering three alternatives. In the first experiment, we set $z_{mt} = z_{m1}$ for all periods, while leaving $\{z_{at}\}$ and $\{\tau_t\}$ as they were in the baseline calibration. In the second experiment we set $z_{at} = z_{a1}$ for all periods, while $\{z_{mt}\}$ and $\{\tau_t\}$ remain the same as in the baseline. Finally, in our third experiment, we keep the tax rate constant, $\tau_t = \tau_1$ for all periods while the sectoral TFPs are allowed to grow as in the baseline calibration.

Figures 7 and 8 depict our results. Qualitatively, they are in line with the intuition indicated in our Introduction: each force drives labor out of agriculture. It should not be surprising, therefore, to see that when a specific exogenous variable stays *constant* at its initial level, the structural transformation is less pronounced than in the baseline calibration.

Quantitatively, agricultural productivity is the most important force driving the structural transformation of the Chinese economy. When agricultural TFP remains constant, the model predicts only 59 percent of the decline in the agricultural employment share in the baseline case (Table 3). When nonagricultural TFP remains constant, however, the model still predicts 88 percent of the baseline case.

The reduction in government size also contributed significantly to China's structural transformation. When the tax rate remains constant at its initial level, the model predicts only 78 percent of its baseline in terms of the agricultural employment share, and 81 percent of the baseline in terms of the agricultural output share (Tables 3 and 4). Our view is that this sectoral transformation was induced through an income effect. The fall in distortions caused by the decline in government activity raised income. Given our non-homothetic utility function, this fall in income resulted in the relative decline in food demand, and a relative decline in agricultural employment.

We do not conduct counterfactual experiments with respect to public employment. The reason is that, as Figure 1 shows, there is no obvious trend for the entire period 1978 to 2003 in the share of public employment that may have driven the transformation of the Chinese economy.[8]

[8] It is true that the share of public employment increased from the mid-1980s to the mid-

5 Conclusion

We presented an aggregate model of the Chinese transition since 1978. Our exercise points out that, besides sectoral differences in productivity growth, the size of the Chinese government is another force that affected the transition of the Chinese economy. Our model provides a device to measure the quantitative importance of this effect relative to productivity growth. Our findings are quantitative, not theoretical. Specifically, we find that, the most important force driving the Chinese transformation is the growth in agricultural productivity. The reduction in the size of the Chinese government also had a significant effect, and appears to be the second most important force driving the transition. Without a reduction in the size of government, the agriculture's share of employment would have declined by less, namely 8 percentage points less, than in the baseline version of our model.

Our model abstracts from a variety of features of the Chinese economy that are additional explanations for the transition that we observe. For example, it has been mentioned that the gradual relaxation of the local registration–or houkou–system, has contributed to the quickening of China's structural transformation since the early 1990s. We leave the analysis in a quantitative growth model of this and other additional explanations of China's transformation to future research.

6 Appendix

6.1 Derivation of the resource constraint

The representative household's budget constraint is

$$c_{mt} + p_t c_{at} + s_{t+1} = \left[w_t \left(1 - h_{gt}\right) + \left(1 + r_t\right) s_t + T_t\right] \left(1 - \tau_t\right)$$

where $T_t = \left[w_t \left(1 - h_{gt}\right) + \left(1 + r_t\right) s_t\right] \tau_t / \left(1 - \tau_t\right)$. Hence, we have

$$c_{mt} + p_t c_{at} + s_{t+1} = w_t \left(1 - h_{gt}\right) + \left(1 + r_t\right) s_t.$$

1990s, owing mainly to the expansion of Township and Village (TVE) enterprises. However, since the mid-1990s, TVE employment has declined so that taking the period 1978-2003 overall, there is no trend in the public employment share.

Using the market clearing condition for labor and savings, the right-hand side becomes

$$w_t (1 - h_{gt}) + (1 + r_t) s_t = w_t h_{mt} + w_t h_{at} + (1 + r_t) (k_{at} + k_{mt} + q_{t-1})$$

or, using the first order conditions of the firms,

$$w_t (1 - h_{gt}) + (1 + r_t) s_t = y_{mt} + (\phi + \mu) p_t y_{at} + (1 - \delta) k_t + (1 + r_t) q_{t-1}.$$

The no-arbitrage condition implies $(1 + r_t) q_{t-1} = i_t + q_t$, thus we obtain

$$w_t (1 - h_{gt}) + (1 + r_t) s_t = y_{mt} + p_t y_{at} + (1 - \delta) k_t + q_t.$$

In the end, the household's budget constraint implies

$$c_{mt} + k_{t+1} = y_{mt} + (1 - \delta) k_t,$$

where the market clearing condition for the agricultural good has been used.

6.2 Employment by Sector

Total employment in State-owned enterprises, Collective and Cooperative units, TVEs, Private and other firms, and the Self-employed are given in the CSY. The CSY also gives the number of employees in each of these sectors that work in agriculture, so we can net out agricultural employment from total employment; and calculate the number of nonagricultural workers in public and private enterprises.[9]

6.3 Prices and GDP by Sector

We follow Young's (2003) methodology by deflating the nominal GDPs reported in the *CSY* not by their GDP deflators, but by other survey based price indices,

[9] Brandt, Hsieh, and Zhu (BHZ, 2005) suggest that the number of agricultural workers reported in the CSY is upward biased, because the CSY assumes that all rural workers are employed in agriculture, when in fact, some rural workers are self-employed or employed in rural industry. BHZ subtract from the total number of agricultural workers, the number of rural workers involved in self-employment and in private enterprises. BHZ's procedure, however, may understate the number of agricultural workers, to the extent that many rural workers have dual jobs, in both agriculture and nonagriculture. Cai, Park, and Zhao (2004) present survey evidence, showing that in 2000, 43 percent of farm household members worked off the farm. Because of the inherent difficulty in classifying rural workers, here we take "as is" the CSY classification of agricultural and nonagricultural workers.

reported in the *CSY*. We deflate primary sector nominal GDP by the general price index of farm products. We deflate secondary sector nominal GDP by the ex-factory industrial price index. We deflate tertiary sector nominal GDP by the service price index. For "industry prices," we take the weighted average of the ex-factory industrial price index and the service price index, where the weights are the nonagricultural GDP shares of the secondary and tertiary sectors.

The *CSY* does not break down GDP, a value added measure, into the public and private sectors for our entire sample period. However, it breaks down nonagricultural *gross* output into the State-owned, Collective, Cooperative, TVE, and the Private sectors, so that nonagricultural gross output can be allocated to each of these sectors. We make the assumption that the share of intermediate inputs is the same in all sectors; so that the ratio of net to gross outputs are the same.[10] We then simply allocate total nonagricultural GDP to the public and private sectors; according to the allocation of gross outputs.

6.4 Capital and Land by Sector

Total gross fixed capital formation (GFCF) is obtained from the *CSY*. The published Chinese national accounts do not provide information on the sectoral distribution of GFCF, but the provincial accounts do. For the period 1978-95, Hsueh and Li (1999) report the sectoral distribution of GFCF in 26 provinces (all provinces other than Jianxi, Guangdong, Hainan, and Tibet), accounting for an average of 78 percent of the annual value of national GFCF. For the remaining period 1996-2003, we obtain the distributional gross fixed capital formation data from the individual *Provincial Statistical Yearbooks*, and aggregate across the privinces. We use the sectoral distribution reported in Hsueh and Li (1999) and in the *Provincial Statistical Yearbooks* to allocate overall national gross capital formation between the agricultural and nonagricultural sectors of the economy.

The *CSY* provides additional data on fixed investment by ownership (State, TVEs, Collective, private, etc.) in the nonagricultural sector. This additional data is compiled from enterprise surveys; and its magnitude is about 10 percent higher than the national income account gross fixed capital formation data, from at least the late 1990s. The coverage of fixed investment in these enterprise surveys seems quite comprehensive, and includes investment in capital construction, research and development, real estate development, and in other

[10] This is not a bad assumption; especially after 2000, where we have data on GDPs for both State-owned and Private firms. In 2002, the ratios of GDP to gross output were about 0.70 in both sectors.

areas. We assume that the discrepancy between the fixed investment data and the national income accounts gross capital formation data are identical across sectors; and use the sectoral distribution in the data on fixed investment to allocate nonagricultural gross capital formation between the public and private sectors of the nonagricultural economy.

To obtain our real investment figures, we must deflate our nominal investment figures. Between 1978 and 1998, we deflate our measures of nominal sectoral investment with Young's (2003, Figure 5) alternative deflator for gross fixed capital formation. Between 1999 and 2003, we construct our own alternative deflator, following the method of Young (2003). With our measures of real sectoral investment from 1978 to 2003 in hand, we can calculate the capital stock using the perpetual inventory method and a 5 percent depreciation rate (as in Young (2003)). We obtain the starting stock of capital at the end of 1978 from Chow (1993).

Finally, while we assume that labor and capital are the only two inputs in the nonagricultural sector, we allow for land inputs in the agricultural sector. We measure total land inputs by the total sown area of farm crops in China (as in McMillan, Whalley, and Zhu, 1989). These data are available in the *CSY*. The total sown area of farm crops has remained essentially fixed, growing at an annualized rate of 0.06 percent between 1978 and 2003.

6.5 Factor Income Shares by Sector

In China, the ratio of compensation by employees to GDP can be estimated using data from the Provincial Statistical Yearbooks. There is clearly an upward trend in the labor share in the provincial data; it rose from 0.42 in 1978 to 0.53 in 1995. We obtained the Provincial Statistical Yearbooks from 1996 to 2003, and calculated nonagricultural labor shares across Chinese provinces for each year. Between 1996 and 2003, the labor share averaged 0.54. Thus, for the entire period, 1978 to 2003, the nonagricultural labor share averaged 0.46. We assume identical labor shares for the public and private Chinese nonagricultural industries.

Using the provincial data assembled by Hsueh and Li (1999) between 1978 and 1995; and the Provincial Statistical Yearbooks from 1996 to 2003, we find that the average labor share in agriculture was 0.76 for the period 1978 to 2003. This is higher than the 0.53 found by Hayami and Ruttan (1985), using Chinese

data in the pre-reform (1978) period, but similar to the 0.70 labor share used in McMillan, Whalley, and Zhu (1989). Hayami and Ruttan (1985) find that the capital share is twice as high as the land share. Chow (1993) estimates a production function for the Chinese agricultural sector using data from 1952 to 1988 and finds that the labor, capital, and land shares are 0.40, 0.25, and 0.35, respectively. Both Hayami and Ruttan (1985) and Chow (1993) include data from the pre-reform period. It is hard to interpret factor shares based on a period when the economy was centrally planned. Because of the lack of reliable data, here we assume identical capital and land shares in agriculture, 0.12. Changing the capital and land shares to 0.16 and 0.08 only negligibly affects our estimates of agricultural total factor productivity.

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	Agriculture	Nonagriculture	Public	Private
Output	5.6	9.1	5.2	24.2
Labor	1.0	4.8	2.5	15.8
Capital	3.5	8.1	6.7	16.6
TFP	4.4	2.4	0.4	6.9

Table 1: Accounting for Total Factor Productivity Growth, (1978-2003; in percent per annum)

Preferences	$\beta = 0.95$, $\bar{c}_a = 0.43$
Technology	$\alpha = 0.54$, $\mu = 0.12$, $\phi = 0.76$, $\delta = 0.05$
	$\{z_{mt}\}$ = data, $z_{m1} = 1.0$
	$\{z_{at}\}$ = data, $z_{a1} = 1.02$
Government	$\{\tau_t\}$ = data
	$\{h_{gt}\}$ = data

Table 2: Baseline calibration

			Constant		
	Data	Base	z_{mt}	z_{at}	τ_t
%age point decline	30	35	31	20	27
Fraction of data decline	1.00	1.16			
Fraction of baseline decline		1.00	0.88	0.59	0.78

Table 3: Agriculture's share of employment

			Constant		
	Data	Base	z_{mt}	z_{at}	τ_t
%age point decline	72	45	40	29	36
Fraction of data decline	1.00	0.62			
Fraction of baseline decline		1.00	0.90	0.64	0.81

Table 4: Agriculture's share of private output

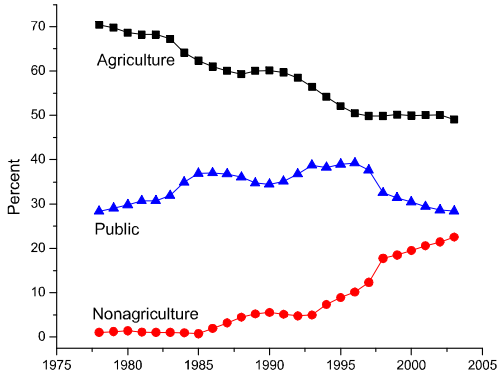

Figure 1: Employment shares

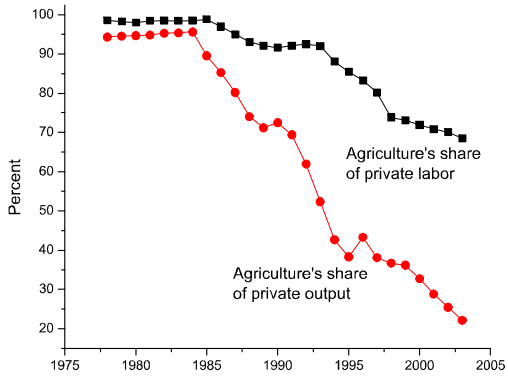

Figure 2: Agriculture's shares of private employment and output

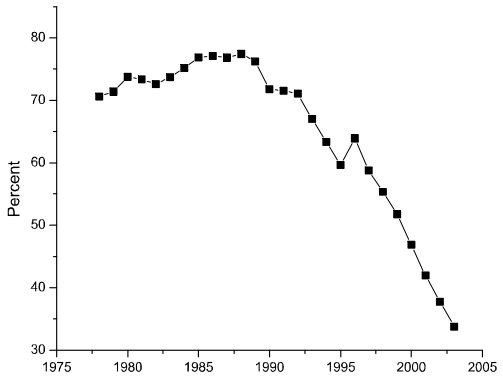

Figure 3: Government's share of total output

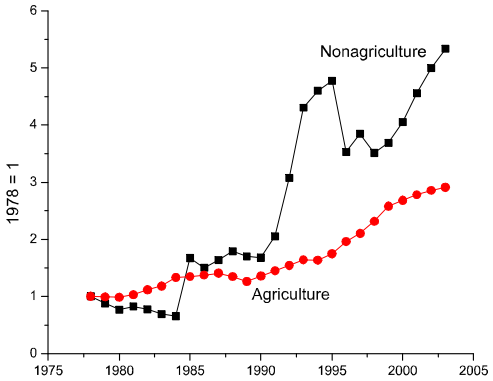

Figure 4: Total factor productivity by sector

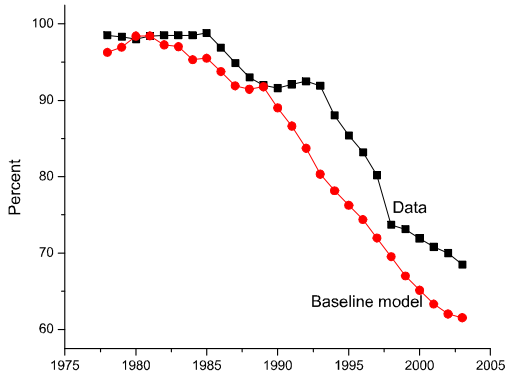

Figure 5: Agriculture's share of private employment: Chinese data and baseline model

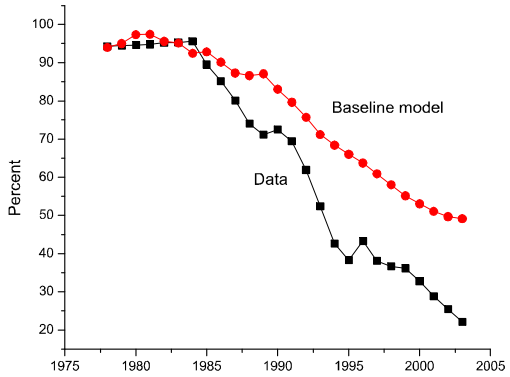

Figure 6: Agriculture's share of private output: Chinese data and baseline model

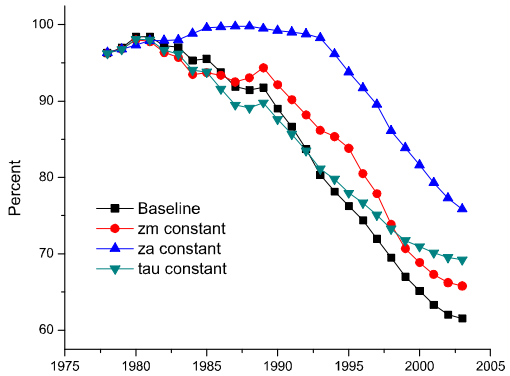

Figure 7: Agriculture's share of private employment: baseline model and counterfactual experiments

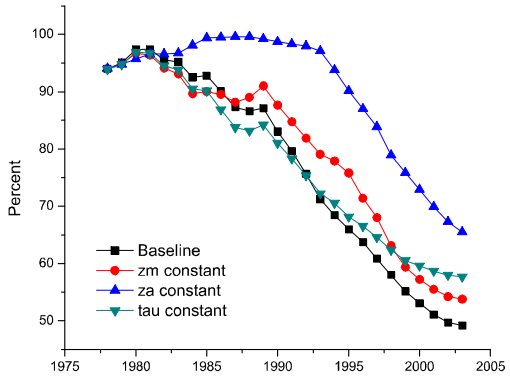

Figure 8: Agriculture's share of private output: baseline model and counterfactual experiments