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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. We find that the reduction in the size of the Chinese government accounted – by itself – for 15% of the reduction in the agricultural share of employment. Two mechanisms explain this: (i) in our model the lower tax rate associated with reduced intervention encouraged the accumulation of physical capital, which is produced in the nonagricultural sector; (ii) lower inefficiencies induced incomes to rise and, given our preferences, resulted in a disproportionate increase in the demand for the nonagricultural good.

1. Introduction

Between 1978 and 2003, the Chinese economy experienced a real annual rate of total GDP growth of 9.6%, 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 6.9% per year. At the same time the Chinese economy experienced what is often labeled a "structural transformation:" resources were reallocated away from the agricultural sector and into nonagricultural 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. We find that the most important force driving the Chinese structural transformation was the growth in agricultural productivity, which accounted for 47% of the reallocation of labor. The reduction in the size of the Chinese government accounted for 15–19%.

Our focus is on the trends in the employment and output shares of agriculture during the period 1978–2003. These trends are depicted in Figs. 1 and 2. Particularly noteworthy is the decline in the relative share of agricultural employment from 70% of all workers in 1978 to less than 50% 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% of all workers by 2003. The share of workers in

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[1] See for example Ngai and Pissarides (2007), Kongsamut et al. (2001), Rogerson (2008) and Duarte and Restuccia (2010). On the structural transformation of China in particular, see Brandt et al. (2008), and Song et al. (2008).

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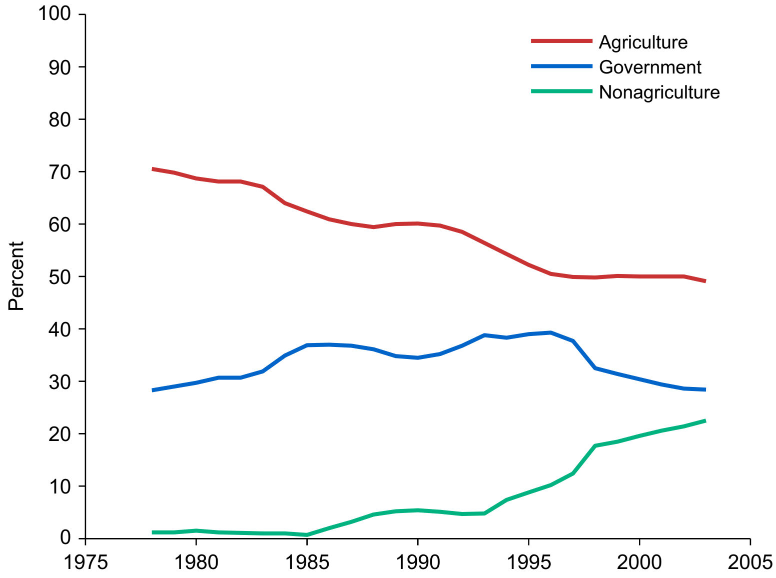

Fig. 1. Sectoral shares of total employment.

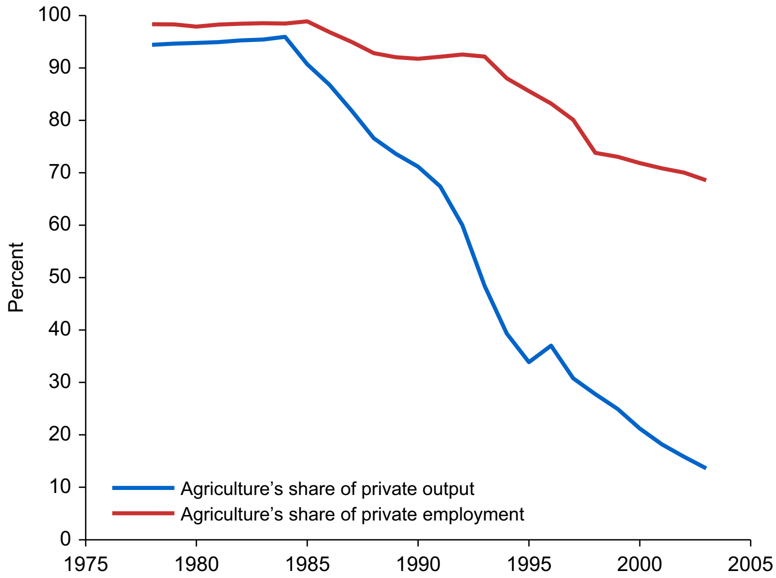

Fig. 2. Agriculture's share of private output and employment.

public industry, while increasing until the mid-1990s, declined since the late 1990s, as State enterprises and Township and Village enterprises (TVEs) were privatized. Fig. 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% of total private output in 1978, it represented only 22% 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), Rogerson (2008) and Duarte and Restuccia (2010).[3] Briefly, in our model set-up, increases in productivity growth in both the agricultural and nonagricultural sectors induce a decline in agriculture's share of employment and output. Specifically, we build a model where the income elasticity of

[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 Duarte and Restuccia, 2010), and those that base structural transformations on sectoral differences in income demand elasticities (Kongsamut et al., 2001). There are also models combining both types of mechanisms (Rogerson, 2008).

agricultural goods is less than unity 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 relative size of the Chinese government which took place during the period we analyze. Namely, in 1978 the government's share of total output was about 70% while in 2003 it was about 40%. We conjecture that reduced government intervention affected the allocation of resources across sectors in China through two distinct mechanisms. First, the lower tax rate associated with reduced intervention encouraged physical capital accumulation. Since physical capital is produced outside the agricultural sector, the demand for nonagricultural labor tends to rise. Second, lower inefficiencies induce income to rise and, given the less than unitary income elasticity of agricultural goods, the demand for nonagricultural labor rises relative to the demand for agricultural labor. Thus, each of the driving variables we consider act toward reallocating resources away from agriculture.

Our characterization of the Chinese government sector captures the "dual-track" nature of China's capitalistic transition. In the early 1980s, Chinese economic planners made a broad commitment to keep the size of the Chinese public sector relatively fixed in absolute terms (Naughton, 2007, Chapter 4). As the private sector expanded, the relative size of the public sector declined, as is the case with our model.

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 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 1.3% and 8.8%, respectively.

In Section 3, we develop the 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 addition, we introduce a "friction" that slows the mobility of labor from agriculture to nonagriculture. This mobility friction is intended to capture the regulatory and discriminatory barriers – such as the *hukou* system – that hinder the ability of the rural, agricultural population from joining the urban, industrial population.

In our paper, the Chinese government is modeled through exogenous sequences of proportional income taxes and government employment. We do not model government policies as the outcome of an optimization problem as in the optimal taxation literature, or as the outcome of a political process as in the political economy literature. Instead, we follow a long list of researchers who consider policy variables as exogenous and examine their effects on various macroeconomic variables. For example, Aiyagari et al. (1990) measure the effect of fluctuations in government consumption on output, employment, and interest rates. Prescott (2004) measures the effect of taxes on labor supply. Cole and Ohanian (2004) study the effects of New Deal policies on the recovery of the Great Depression. Chen et al. (2006) measure the effects of the capital income tax rate on the Japanese saving rate. Although endogenizing policy variables can be of interest per se, it would prevent us from examining the effects of exogenous policy variables (in our case, proportional income taxes and government employment) on endogenous variables (in our case, the agricultural shares of output and employment) by performing the counterfactual experiments that we perform in Section 4.

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 our data on the share of government output in total output. 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 driving forces to 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). The data come mainly from the CSY of 2009, which includes the data revisions performed in 2006, that substantially raised the value of tertiary (services) sector output starting in 1998 (Holtz, 2006). Details on the data construction are given in the Appendix. The main data 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.

Table 1
Accounting for total factor productivity growth (1978–2003; in percent per annum).

	Agriculture	Nonagriculture	Public	Private
Output	4.5	10.6	6.7	26.0
Labor	1.0	4.1	1.9	14.6
Capital	3.7	9.8	8.4	16.7
TFP	3.7	3.2	1.3	8.8

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, 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.[4] From hereon in this paper, we will refer to the nonagricultural public sector as the "public" or the "government" sector, and the nonagricultural private sector as simply the "nonagricultural sector."

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.

We find an annual growth rate of TFP of 3.7% in agriculture compared to 8.8% in the private nonagricultural sector. We also find little growth (1.3%) in the public sector. This finding of negative or very small productivity growth in Chinese state industries is consistent with Jefferson et al. (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% and 46% 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 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% 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 government work, while the remaining $1-h_{gt}$ units of time are allocated optimally between the agricultural and nonagricultural private sectors. We assume that mobility between the agricultural

[4] 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, Chapter 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, Chapter 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.

sector and the nonagricultural private sector is not perfect by imposing a time cost ρ_t that must be paid each period by the representative household when it moves from agriculture to nonagriculture. Thus, a unit of time spent away from government work and agriculture work yields only $1-\rho_t$ unit of work time in the nonagricultural sector.[5]

In modeling the public side of the Chinese economy, we must take into account the fact that between the late 1970s and the mid-1990s, public output accounted for much more than 50% 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

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

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 $\overline{c}_a > 0$ 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

$$c_{mt} + p_t c_{at} + s_{t+1} = [w_{at}h_{at} + w_{mt}(1-\rho_t)h_{mt} + (1+r_t)s_t + T_t](1-\tau_t) \tag{2}$$

and the time constraint is

$$h_{at} + h_{mt} + h_{gt} = 1 \tag{3}$$

Remember that h_{gt}, the time devoted to government work, is not a choice variable. Instead it is interpreted as a tax levied on the household's time. Household saving during period t is denoted by s_{t+1} and the hours devoted to the agricultural and nonagricultural private sectors are denoted by h_{at} and h_{mt}. The term T_t is a transfer received from the government. Note that the wage rates, w_{at} and w_{mt}, paid for hours worked in the private sectors are sector-specific, owing to the mobility costs. 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.

The first order conditions for utility maximization are

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

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

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

$$h_{at} : 0 = w_{at} - (1-\rho_t)w_{mt}$$

where λ_t is the Lagrange multiplier associated with the budget constraint of period t and the time constraint (3) has been used to substitute out h_{mt}. The first two equations imply

$$\frac{c_{mt}}{p_t c_{at}} = \frac{\gamma}{1-\gamma}\left(1 - \frac{\overline{c}_a}{c_{at}}\right) \tag{4}$$

This equation illustrates one of the forces at work in the model. It shows that when consumption of the agricultural good increases, expenditures on the nonagricultural good increases faster than on the agricultural good, i.e., $c_{mt}/(p_t c_{at})$ increases. This feature is the result of the non-homotheticity introduced in preferences through the subsistence level of consumption, $\overline{c}_a$. This faster increase in nonagricultural expenditures induces labor to move into the nonagricultural sector.

The third equation is the Euler condition:

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

[5] This mobility or time cost includes the effects of the *hukou*, or the household registration system. The *hukou* system categorically divides the rural, and hence mostly agricultural populations from the urban, and hence industrial populations. It is said that the *hukou* system discourages rural to urban migration by outright prohibiting this migration, or more recently, denying pension, health, education, and other benefits to rural migrants. This discriminatory treatment of rural migrants has ebbed and flowed between 1978 and 2003, but has generally decreased over time.

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 which, in turns, fuels the demand for labor in the nonagricultural sector. In Section 3.6 we discuss in more detail the effect of τ_t on the sectoral allocation of labor.

Finally, note that the last condition implies a wedge between the agricultural and nonagricultural wage rates:

$$\frac{w_{at}}{w_{mt}} = 1-\rho_t$$

A reduction in the cost of moving across sectors has two opposite effects. On the one hand, it increases the relative agricultural wage rate, thereby lowering the incentive for farmers to move out of agriculture, helping increase agricultural employment. On the other hand, everything else being equal, a decline in the mobility cost raises overall labor income (from the budget constraint of the household (2)). Because of the non-homotheticity of the utility function, the consumption of the nonagricultural good rises relatively faster, increasing labor demand in the non-agricultural sector, and helping decrease agricultural employment. We show analytically below that the second effect dominates.

3.3. The firms

In the private nonagricultural sector, the technology is given by

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

where $\alpha \in (0,1)$ is the capital share. In the agricultural sector it is

$$y_{at} = F_a(k_{at}, n_{at}) = z_{at} k_{at}^{\mu} n_{at}^{\phi}$$

where $\mu, \phi \in (0,1)$ and $\mu+\phi \in (0,1)$. The variables n_{jt} and k_{jt} $(j = a, m)$ represent employment in sector j and the capital stock, respectively. The variables z_{mt} and z_{at} are exogenous, sector-specific Total Factor Productivity terms. We assume that these Total Factor Productivity terms grow at constant, sector-specific rates, i.e., $z_{jt} = z_{j1} g_j^{t-1}$ $(j = a, m)$, and we normalize the initial value of z_{m1} to unity, i.e., $z_{m1} = 1$. The nonagricultural sector solves

$$\max \{F_m(k_{mt}, n_{mt}) - w_{mt} n_{mt} - (r_t+\delta) k_{mt}\} \tag{5}$$

and the agricultural sector solves

$$\max \{p_t F_a(k_{at}, n_{at}) - w_{at} n_{at} - (r_t+\delta) k_{at} - i_t\} \tag{6}$$

The first order conditions for profit maximization are

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

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

$$n_{mt} : (1-\alpha) z_{mt} k_{mt}^{\alpha} n_{mt}^{-\alpha} = w_{mt}$$

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

Combining and using the fact that $w_{at}/w_{mt} = 1-\rho_t$ yields

$$\frac{n_{mt}}{n_{at}} = (1-\rho_t)\frac{1-\alpha}{\alpha}\frac{\mu}{\phi}\frac{k_{mt}}{k_{at}} \tag{7}$$

At the beginning of a period, the stock of capital is predetermined. Thus, this equation shows how a lower mobility cost increases the fraction of workers in the nonagricultural sector: n_{mt}/n_{at}. Later we also use this equation to calibrate the time path of ρ_t.

3.4. 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. The government's budget is

$$T_t = [w_{at} h_{at} + w_{mt}(1-\rho_t) h_{mt} + (1+r_t) s_t + T_t]\tau_t = \frac{\tau_t}{1-\tau_t}[w_{at} h_{at} + w_{mt}(1-\rho_t) h_{mt} + (1+r_t) s_t] \tag{8}$$

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." Also, note from the second equation that transfers, T, 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.

One interpretation of this budget constraint is as follows. Let private income at the beginning of period t be denoted by $x_t = w_{at} h_{at} + w_{mt}(1-\rho_t) h_{mt} + (1+r_t) s_t$. 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 within 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 $T_t = \sum_i \tilde{T}_{it} = x_t \tau_t/(1-\tau_t)$.

3.5. Equilibrium

3.5.1. Definition

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

$$h_{mt}(1-\rho_t) = n_{mt}$$

and

$$h_{at} = n_{at}$$

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. Note that the presence of three assets implies that a no-arbitrage condition must hold

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

that is, the gross rate of interest 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. Eqs. (5) and (6) 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.

We assume that the agricultural good is used only for consumption, hence in equilibrium

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

Finally the market clearing condition for nonagricultural goods is

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

which can be derived from substituting the equilibrium and no-arbitrage conditions into the household's budget constraint (see Appendix for details).

Definition 1. Given a sequence of taxes $\{\tau_t\}$, public employment $\{h_{gt}\}$, and moving cost $\{\rho_t\}$, an equilibrium is a sequence of prices $\{w_t, r_t, i_t, p_t, q_t\}$ and allocations for firms $\{k_{mt}, h_{mt}\}$ and $\{k_{at}, h_{at}\}$, and the household $\{c_{mt}, c_{at}, s_{t+1}\}$ such that

1. The sequence $\{c_{mt}, c_{at}, s_{t+1}\}$ maximizes (1) subject to (2) and (3) given prices;
2. The sequence $\{k_{mt}, h_{mt}\}$ solves (5) given prices, at every period;
3. The sequence $\{k_{at}, h_{at}\}$ solves (6) given prices, at every period;
4. Markets clear.

3.5.2. Steady state analysis of the effects of the "tax rate" and productivity

Although our model does not have an analytical solution, some intuition about its mechanism can be gained by analyzing its behavior in a steady state. We show in the Appendix that in a steady state, the following equation characterizes the equilibrium share of employment in the agricultural sector:

$$\frac{\gamma}{1-\gamma}\left(1-\frac{\overline{c}_a}{y_a}\right)\frac{\alpha}{\mu}\Sigma n_a = (1-h_g-n_a)\left(1-\frac{\delta\alpha(1-\Sigma)}{\frac{1/\beta}{1-\tau}+\delta-1}\right)-\frac{\delta\alpha}{\frac{1/\beta}{1-\tau}+\delta-1}(1-h_g)\Sigma \tag{9}$$

where $\Sigma = ((1-\alpha)/\alpha)\mu/\phi$ is a positive constant and $\Sigma \in (0,1)$ in our calibration.

Observe that the left-hand side of Eq. (9) is an increasing function of n_a, while its right-hand side is decreasing.[6] Hence, we can represent the determination of an equilibrium as the intersection of two curves: one for the left-hand side, that is

[6] The fact that the right-hand side of (9) is decreasing in n_a can be deduced by observing that both the left- and the right-hand sides are positive. Since the intercept of the right-hand side is negative, the term

$$1-\frac{\delta\alpha(1-\Sigma)}{\frac{1/\beta}{1-\tau}+\delta-1}$$

must be positive, hence the right-hand side is decreasing in n_a.

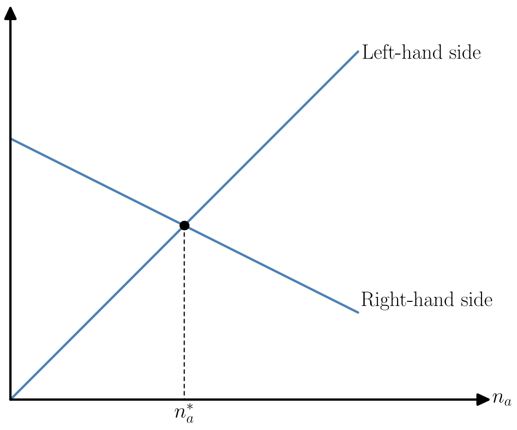

Fig. 3. Determination of agriculture's share of employment in a steady state.

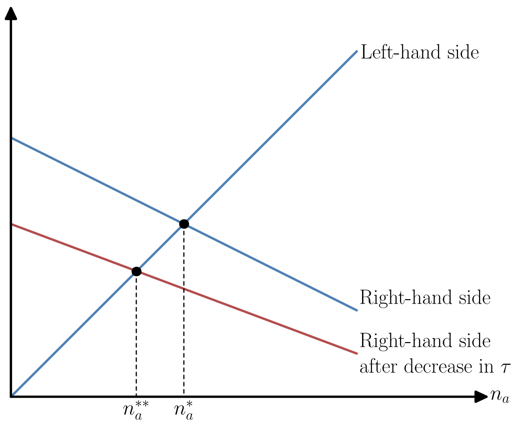

Fig. 4. Effect of a reduction in the tax rate τ on agriculture's share of employment in a steady state where $\overline{c}_a/y_a \simeq 0$.

nonagricultural consumption, and the other for the right-hand side, that is nonagricultural output net of depreciation. Fig. 3 gives such a representation.[7]

To analyze the effect of a change in the tax rate on the sectoral allocation of labor, we examine how Eq. (9) is affected by a decrease in τ. In a steady state, agricultural output is

$$y_a = z_a z_m^{\mu/(1-\alpha)} \left((1-\rho)\Sigma \left(\left(\frac{1/\beta}{1-\tau} + \delta - 1 \right) \Big/ \alpha \right)^{1/(\alpha-1)} \right)^{\mu} n_a^{\phi+\mu} \tag{10}$$

which is a decreasing function of τ (see the Appendix for the derivation of Eq. (10)). Since the left-hand side of (9) is increasing in y_a, it is therefore decreasing in τ. We can see that the right-hand side of Eq. (9) is an increasing function of the tax rate τ.

We can now analyze the effect of the tax rate τ on the sectoral allocation of labor. There are two distinct mechanisms, the second magnifying the effect of the first. First suppose that $\overline{c}_a/y_a$ is negligibly small. Then, a decrease in the tax rate τ reduces the value of the right-hand side of (9) for all n_a (see Fig. 4). Thus as τ decreases, firms choose higher levels of capital per worker, and since capital is produced in the nonagricultural sector, the demand for nonagricultural labor rises relative to the demand for agricultural labor.

The second, magnifying mechanism becomes relevant when $\overline{c}_a/y_a$ is not negligible. This effect is a consequence of the non-homotheticity of preferences. As the level of income increases, due to the reduced level of taxation, the household increases its spending on nonagricultural consumption faster than on agricultural consumption. As a result there is a relative increase in the demand for nonagricultural labor, raising the left-hand side of (9) for all values of n_a. Thus, the decrease in the labor share of the agricultural sector is magnified, as shown in Fig. 5.

Next we turn to the effect of productivity on the sectoral allocation of labor. Note that the productivity terms z_m and z_a enter Eq. (9) only through the term $\overline{c}_a/y_a$. Thus, at high levels of output, when $\overline{c}_a/y_a \to 0$, productivity does not affect the allocation of labor across sectors. At lower levels of output, however, increases in z_m and/or z_a raise y_a (see Eq. (10)) and the

[7] For simplicity, Fig. 3 represents the right- and left-hand sides of Eq. (9) as linear functions of n_a, while the left-hand side is linear only when $\overline{c}_a = 0$.

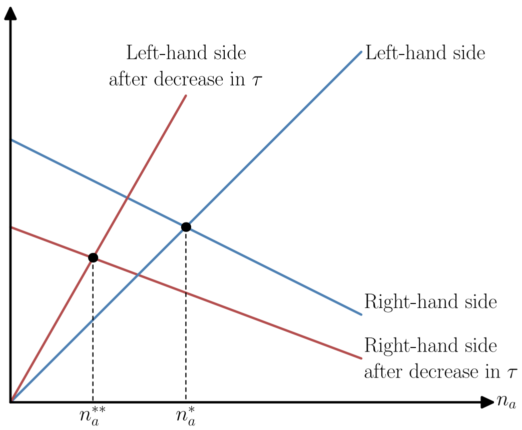

Fig. 5. Effect of a reduction in the tax rate τ on agriculture's share of employment in a steady state where $\overline{c}_a/y_a>0$.

left-hand side of (9), lowering the demand for agricultural labor. Note that different growth rates for sector-specific productivity are not necessary to generate changes in the sectoral allocation of labor. That is, at low levels of output, the reallocation of labor away from agriculture can occur even when z_m and z_a grow at the same rate. This prompts the question: how much of the reallocation of labor away from agriculture is due to differences in productivity growth between sectors? In the next section we conduct an experiment to provide a quantitative answer to this question.

4. Quantitative analysis

The quantitative exercise is the following. First, we choose a time path for the exogenous driving forces: $\{z_{mt}, z_{at}, \tau_t, h_{gt}, \rho_t\}$. 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. Finally, there are three parameters not pinned down by this exercise: the subsistence level of agricultural consumption, $\overline{c}_a$, the initial level of agricultural TFP, z_{a1}, and the initial 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 data counterparts in 1978.

We emphasize that we do not attempt to fit our model to the entire time paths of agricultural employment or output shares. 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 transition paths under a set of counterfactual examples regarding the driving forces of the model. These exercises allow us the assess what mechanisms are quantitatively the most important in generating our baseline results.

4.1. Calibration

The factor shares α, μ and ϕ are discussed in Section 2 and in the 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 $\beta=0.97$ and $\delta=0.05$. We choose $\gamma=0.95$ so that in the long-run, the share of employment in nonagriculture is 95%.

The exogenous forces driving the model economy are total factor productivity in each sector, $\{z_{mt}\}$ and $\{z_{at}\}$, the proportional income tax rate, $\{\tau_t\}$, the moving cost, $\{\rho_t\}$, and the public employment rate, $\{h_{gt}\}$. We use our data on output, capital and employment by sector, as well as the factor shares, to construct our time series for Total Factor Productivity (TFP) in agriculture and in nonagriculture. As mentioned earlier, the average annual rate of TFP growth of private nonagriculture is 8.8% and 3.7% in agriculture. Thus we set $g_m=1.088$ and $g_a=1.037$, i.e.

$$z_{mt}=1.088^{t-1}$$

and

$$z_{at}=z_{a1}1.037^{t-1}$$

We will explain below how we determine the initial level of TFP in non-agriculture, z_{a1}. Fig. 6 shows the time paths of sectoral TFP used in the baseline calibration.

To calibrate the sequence of tax rates $\{\tau_t\}$ we use the (HP-filtered) share of public output to total output, as shown in Eq. (8). The tax rate calibrated in this way is represented in Fig. 7. It decreases from the neighborhood of 70% to about 40%, implying that the government sector went from being $0.7/(1-0.7)=2.3$ times bigger than the private sector in 1978 to being close to two-third of its size by 2003 $(0.4/(1-0.4)=0.66)$. We need to take a stand on the path of τ_t beyond 2003. In our baseline exercise, we assume that it remains constant after 2003.

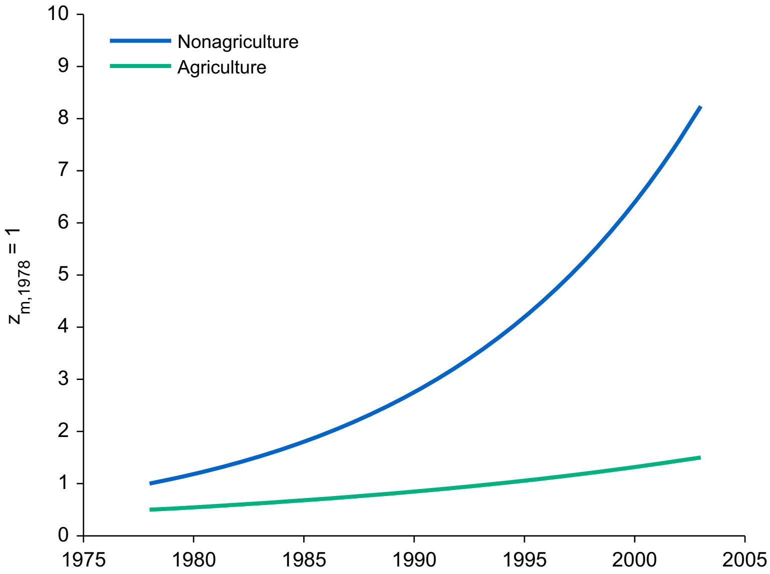

Fig. 6. Time path of exogenous total factor productivity by sector, normalized to 1, in 1978, in nonagriculture.

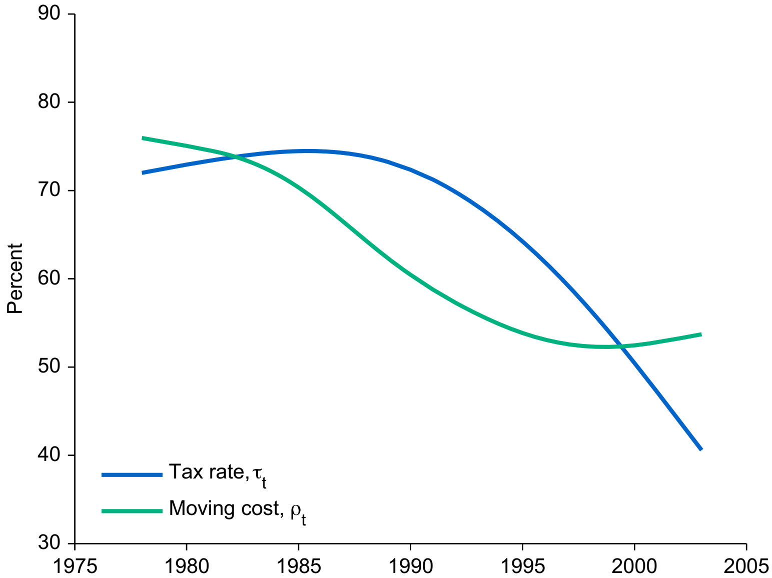

Fig. 7. Time path for the income tax rate and the moving cost, HP-filtered.

Finally we calibrate the mobility cost $\{\rho_t\}$ using Eq. (7). That is, using the factor shares and our data on capital and employment in each sector, we use Eq. (7) to construct a (HP-filtered) time series for $\{\rho_t\}$. Fig. 7 depicts the mobility cost calibrated in this way. We find that in the late 1970s, the mobility cost was about 75%, and that it decreased to about 55% by 2003. We assume that after 2003, the mobility cost remains constant at its 2003 level.

We use the actual sequence of public employment for $\{h_{gt}\}$ (see Fig. 1). Note that there is no obvious trend in the share of public employment for the entire period 1978–2003. It is true that the share of public employment increased from the mid-1980s to the mid-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 as a whole, there is no trend in the public employment share. We assume that past 2003, the share of public employment remains constant at its average level of 28%.[8]

[8] We experimented with alternative assumptions regarding the behavior of public employment, and other exogenous variables, beyond 2003, and found little differences in the results. This is because in our model, like in the optimal growth model, the solution can be represented by a 2nd order

Table 2
Baseline calibration.

Preferences	$\beta=0.97$, $\overline{c}_a=0.35$, $\gamma=0.95$
Technology	$\alpha=0.54$, $\mu=0.12$, $\phi=0.76$, $\delta=0.05$
	$\{z_{mt}\}=$ data, $z_{m1}=1.0$
	$\{z_{at}\}=$ data, $z_{a1}=0.58$
Government	$\{\tau_t\}=$ data on relative size of public output
	$\{h_{gt}\}=$ data on public employment
Moving cost	$\{\rho_t\}=$ data relative capital per workers across sectors

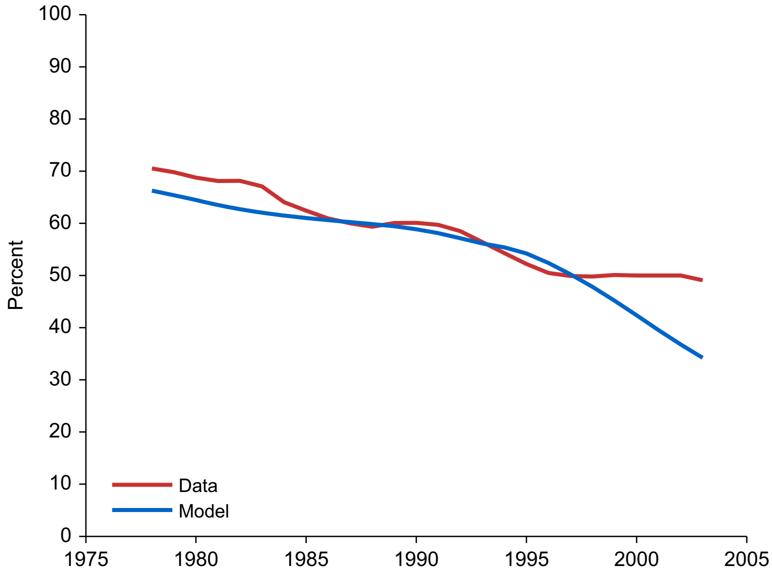

Fig. 8. Agriculture's share of employment: baseline model and data.

Three parameters remain: $\overline{c}_a$, the subsistence level of consumption, z_{a1}, the initial level of agricultural TFP and k_{m1} the initial stock of capital in the nonagricultural sector.[9] We pick them to minimize the distance between the model and the data, in terms of the initial share of agricultural employment and output:

$$\min_{\overline{c}_a, z_{a1}, k_{m1}} (h_{a1}-0.70)^2+\left(\frac{py_{a1}}{p_1 y_{a1}+y_{m1}}-0.94\right)^2+\left(\frac{k_{m1}}{y_{m1}}-15.25\right)^2$$

4.2. Results

Below, we described the behavior of the economy under our baseline calibration. Then, we analyze the effects of productivity, taxes and mobility costs by performing a set of counterfactual exercises.

4.2.1. Baseline economy

Our baseline calibration is displayed in Table 2. Figs. 8 and 9 depict the model's prediction for the employment and output shares of agriculture compared to their empirical counterparts. The mechanisms at work in our baseline exercise tend to overpredict the transition of employment out of agriculture, but underpredict the shift in output from agriculture to nonagriculture.

The first two columns of Tables 3 and 4 report the performance of the baseline model. In the Chinese data, agriculture's share of total employment exhibits a 21 percentage point drop (from 70 to 49% of the total labor force). Our baseline model predicts a 32 percentage point decline, overpredicting the movement of labor out of agriculture by 50%. For output, the Chinese data show an 81 percentage point decline in the output of the agricultural sector, relative to the output of the

(*footnote continued*)
difference equation. Hence to make optimal decisions at date t, it is sufficient to know the values of the state variables at t and $t+1$. Thus, alternative assumptions about the behavior of, say TFP, after 2003 have only a limited effect on decisions prior to 2003.

[9] The first order conditions of the firm imply that, given the mobility cost ρ_t, 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.

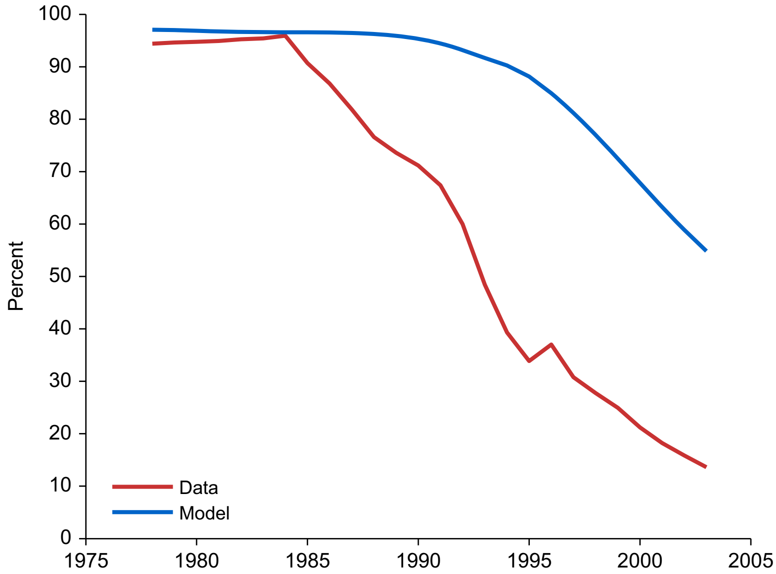

Fig. 9. Agriculture's share of private output: baseline model and data.

Table 3
Decline in agriculture's share of employment: data, baseline model and counterfactual experiments.

			Constant					
	Data	Base	z_{at}	z_{mt}	τ_t	ρ_t	τ_t, ρ_t	$g_m = g_a$
Percentage point decline	21	32	17	20	27	30	26	26
Fraction of data	1.00	1.50						
Fraction of base		1.00	0.52	0.63	0.86	0.94	0.80	0.80

Note: In the last experiment we set the growth rates agricultural and nonagricultural TFP at the rate of agricultural TFP growth in the data: 3.7% per year.

Table 4
Decline in agriculture's share of private output: data, baseline model and counterfactual experiments.

			Constant					
	Data	Base	z_{at}	z_{mt}	τ_t	ρ_t	τ_t, ρ_t	$g_m = g_a$
Percentage point decline	81	42	22	26	36	25	20	34
Fraction of Data	1.00	0.67						
Fraction of Base		1.00	0.51	0.63	0.85	0.59	0.47	0.81

Note: In the last experiment we set the growth rates agricultural and nonagricultural TFP at the rate of agricultural TFP growth in the data: 3.7% per year.

private sector. Our baseline model predicts a 42 percentage point decline in the agricultural output share, which is only 67% of the actual decline in the output share.

There are two reasons why our model does not perfectly fit the Chinese data. First, we calibrated the model to one point in time, and left the time series behavior of the model unconstrained. Second, there are forces at work in the Chinese economy that we did not model. We suggest, however, that we can still learn from our exercise since adding additional forces to the model does not necessarily imply that our driving forces would play less of a role.

4.2.2. *The effects of productivity*

In a first set of counterfactual experiments, we simulate our model under alternative paths for TFP in the agricultural and nonagricultural sectors. Namely, we set $z_{at} = z_{a1}$ for all periods, while leaving $\{z_{mt}, \tau_t, \rho_t\}$ as they were in the baseline. In the second set of counterfactual experiments, we set $z_{mt} = z_{m1}$ for all periods, while $\{z_{at}, \tau_t, \rho_t\}$ remain the same as in the

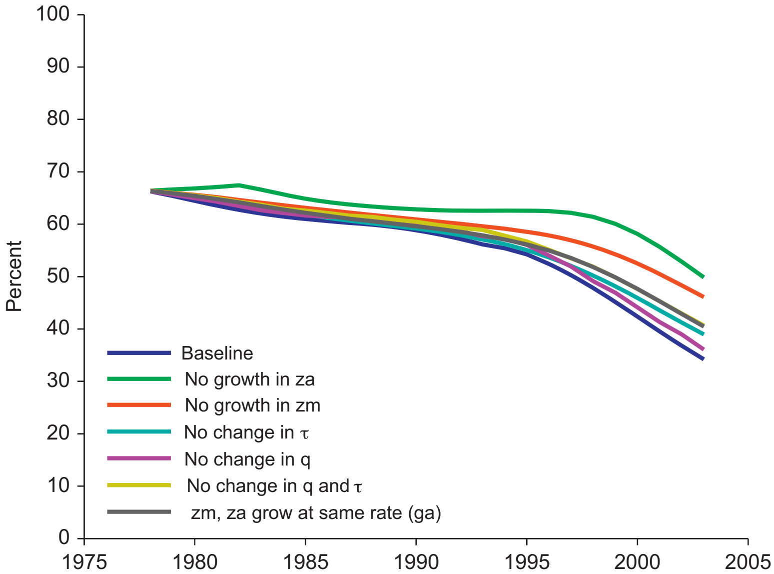

Fig. 10. Agriculture's share of employment: baseline model and counterfactual experiments.

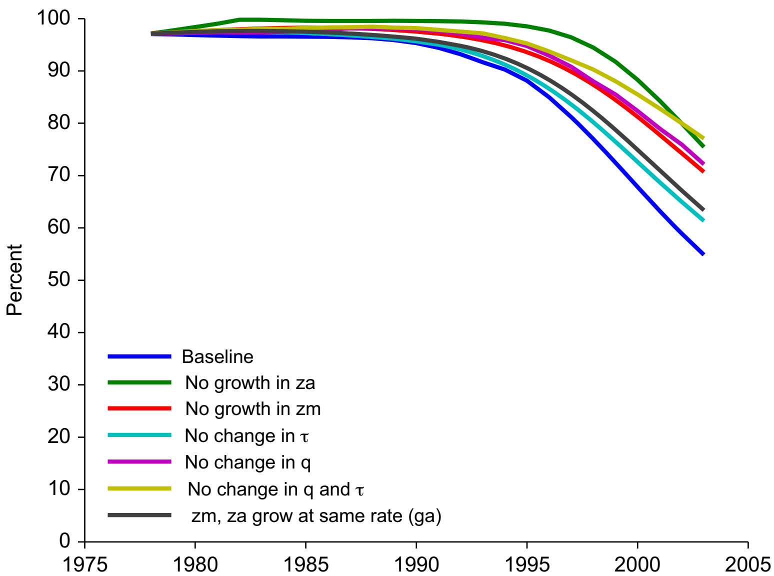

Fig. 11. Agriculture's share of private output: baseline model and counterfactual experiments.

baseline. Figs. 10 and 11 show the results of these counterfactual experiments for the agricultural employment share and the agricultural output share, as compared to the baseline. The third and fourth columns of Tables 3 and 4 report the quantitative exercises.

When agricultural TFP remains constant at its initial level, the employment share of agriculture falls by 17 percentage points, compared to the 32 percentage point decline in the baseline. Thus, agricultural TFP alone accounts for $(1-17/32)\simeq 47\%$ of the reduction in the agricultural employment share. For the agricultural output share, we find that the experiment with constant agricultural TFP results in a decline of 22 percentage points, compared to a 42 percentage points decline in the baseline. Thus, the contribution of agricultural TFP to the decline in the agricultural output share is $(1-22/42)=48\%$. Similarly, we find that the experiment where nonagricultural TFP is held constant accounts for $(1-20/32)=36\%$ of the decline in the agriculture employment share, and $(1-26/42)=38\%$ of the decline in the agricultural output share.

We conduct an additional experiment, reported in the last columns of Tables 3 and 4, to assess the importance of the sectoral difference in TFP growth rates. We do so by ''shutting down'' the difference, by assuming that the rate of growth of

TFP in the nonagricultural sector is the same as in the agricultural sector, that is 3.7% per year (instead of 8.8%). Our simulation reveals that the employment share of agriculture falls by 26 percentage points under this assumption. Thus, the fact that nonagricultural TFP grows faster than agricultural TFP by itself accounts for $(1-26/32)=19\%$ of the reallocation of labor away from agriculture. In terms of the agricultural share of output, we find a reduction of 34 percentage points, when agricultural TFP grows at the same rate as nonagricultural TFP. Thus, the gap in sectoral TFP growth accounts for $(1-34/42)=19\%$ of the reallocation of output.

4.2.3. The effects of taxes and the mobility costs

We now consider the effect of maintaining the tax rate τ_t constant at its initial level of 70%. The quantitative result of this exercise is reported in the fifth columns of Tables 3 and 4. We find that when the tax rate (the size of the Chinese government) stays constant, the reduction in the agricultural employment share is 27 percentage points, which is less than the baseline reduction of 32 percentage points. The tax rate by itself accounts for $(1-27/32)=15\%$ of the decline in the agricultural employment share. For the agricultural output share, the contribution of the decline in the tax rate is similar, explaining about 15% of the baseline reduction.

The mechanism through which a reduction in the size of the Chinese government leads to a reallocation of labor out of agriculture was discussed in Section 3: a reduction in the tax rate allows for the growth in nonagricultural consumption and physical capital accumulation to be faster, resulting in a rise in the demand for labor in the nonagricultural sector.

Next we consider an experiment where the mobility cost ρ_t remains constant at its initial level. We find that the reduction in the mobility cost affects the reallocation of labor, but the effect is moderate. The reduction in the agricultural employment share is 30 percentage points when ρ_t remains constant, compared to a 32 percentage point reduction in the baseline. One reason for the moderate effect of the reduction in the mobility cost is that such a reduction has opposing effects (from Section 3). On the one hand, a reduction in the mobility cost raises disposable income, increasing consumption. Given the non-homotheticity of preferences, the demand for labor in the nonagricultural sector increases. On the other hand, however, a reduction in the moving cost raises relative wages in agriculture, lowering the incentives to move out of agriculture.

Our last experiment holds *both* the tax rate τ_t and the moving cost ρ_t constant. The rationale for this experiment is that both τ_t and ρ_t are "frictions," in the main created by Chinese government policy. It is thus important to evaluate the combined effect of these "frictions" on China's structural transformation. We find (see last columns of Tables 3 and 4) that when both τ_t and ρ_t are held constant, the effect on the reallocation of labor and output out of agriculture is quite noticeable: $(1-26/32)=19\%$ of the reallocation of labor is accounted for by only these two factors.

5. Conclusion

We presented a model of China's structural transformation since 1978. Our exercise suggests that besides productivity growth, the size of the Chinese government (as measured by taxes), and restrictions to labor mobility are key forces affecting the structural transformation of the Chinese economy. Our model provides a way to measure the quantitative importance of each of these forces. Our findings are quantitative, not theoretical. Specifically, we find that the most important force driving the Chinese structural transformation is the growth in agricultural productivity. The reduction in the size of the Chinese government also has a significant effect: taxes alone account for 15% of the reallocation of labor out of agriculture, and the combination of the reduction in taxes and in mobility costs account for 19% of this labor reallocation.

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Appendix A. Derivation of the resource constraint

The budget constraint of the representative agent is

$$c_{mt}+p_t c_{at}+s_{t+1}=[w_{at}h_{at}+w_{mt}(1-\rho_t)h_{mt}+(1+r_t)s_t+T_t](1-\tau_t)$$

where

$$T_t=[w_{at}h_{at}+w_{mt}(1-\rho_t)h_{mt}+(1+r_t)s_t+T_t]\tau_t=\frac{\tau_t}{1-\tau_t}[w_{at}h_{at}+w_{mt}(1-\rho_t)h_{mt}+(1+r_t)s_t]$$

Hence the budget constraint of the individual becomes

$$c_{mt}+p_t c_{at}+s_{t+1}=w_{at}h_{at}+w_{mt}(1-\rho_t)h_{mt}+(1+r_t)s_t$$

$$c_{mt}+p_t c_{at}+k_{m,t+1}+k_{a,t+1}+q_t=w_{at}n_{at}+w_{mt}n_{mt}+(1+r_t)(k_{mt}+k_{at}+q_{t-1})$$

where the market clearing conditions for labor and savings have been used. Then, using the firms' first order conditions for profit maximization, we have

$$c_{mt}+p_t c_{at}+k_{m,t+1}+k_{a,t+1}+q_t=p_t\phi y_{at}+(1-\alpha)y_{mt}+(1+r_t)(k_{mt}+k_{at}+q_{t-1})$$

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

$$\begin{aligned}c_{mt}+p_t c_{at}+k_{m,t+1}+k_{a,t+1}+q_t&=p_t\phi y_{at}+(1-\alpha)y_{mt}+(1+r_t)(k_{mt}+k_{at})+i_t+q_t\\&=p_t\phi y_{at}+(1-\alpha)y_{mt}+\alpha y_{mt}+p_t\mu y_{at}+(1-\delta)(k_{mt}+k_{at})+i_t+q_t=y_{mt}+p_t y_{at}+(1-\delta)(k_{mt}+k_{at})+q_t\end{aligned}$$

Finally, the market clearing condition for the agricultural good implies

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

Appendix B. Steady state

In a steady state, the resource constraint is

$$c_m=y_m-\delta(k_m+k_a)$$

Nonagricultural output can be expressed as $y_m=z_m(k_m/n_m)^\alpha n_m$, and using Eq. (7) we can write $k_a/n_a=(1-\rho)\Sigma k_m/n_m$ where $\Sigma=((1-\alpha)/\alpha)\mu/\phi$. Then, the total capital stock, k_m+k_a, can be expressed as

$$k_m+k_a=\frac{k_m}{n_m}(n_m+(1-\rho)\Sigma n_a)=\frac{k_m}{n_m}[n_m(1-\Sigma)+(1-\rho)(1-h_g)\Sigma]$$

where the second equality is derived from the labor market clearing conditions. Hence, in a steady state

$$c_m=z_m\left(\frac{k_m}{n_m}\right)^\alpha n_m-\delta\frac{k_m}{n_m}[n_m(1-\Sigma)+(1-\rho)(1-h_g)\Sigma]$$

Eq. (4) and the market clearing condition for the agricultural good imply

$$c_m=\frac{\gamma}{1-\gamma}\left(1-\frac{\overline{c}_a}{y_a}\right)py_a$$

where $y_a=z_a(k_a/n_a)^\mu n_a^{\phi+\mu}$. Combining the first order conditions of each firm, with respect to their stock of capital, imply

$$py_a=\frac{\alpha}{\mu}z_m\left(\frac{k_m}{n_m}\right)^\alpha(1-\rho)\Sigma n_a$$

Thus, the equilibrium condition on the nonagricultural good's market can be written as

$$\frac{\gamma}{1-\gamma}\left(1-\frac{\overline{c}_a}{y_a}\right)\frac{\alpha}{\mu}(1-\rho)\Sigma n_a=n_m-\delta z_m^{-1}\left(\frac{k_m}{n_m}\right)^{1-\alpha}[n_m(1-\Sigma)+(1-\rho)(1-h_g)\Sigma]$$

The Euler equation implies that $\beta(1+r)(1-\tau)=1$, hence the stock of capital per worker, in the nonagricultural sector, is determined by

$$\alpha z_m\left(\frac{k_m}{n_m}\right)^{\alpha-1}=\frac{1/\beta}{1-\tau}+\delta-1$$

Note that this equation implies that the stock of capital per worker is a decreasing function of the tax rate τ. The equilibrium condition can now be written as

$$\frac{\gamma}{1-\gamma}\left(1-\frac{\overline{c}_a}{y_a}\right)\frac{\alpha}{\mu}\Sigma n_a=(1-h_g-n_a)\left(1-\frac{\delta\alpha(1-\Sigma)}{\frac{1/\beta}{1-\tau}+\delta-1}\right)-\frac{\delta\alpha}{\frac{1/\beta}{1-\tau}+\delta-1}(1-h_g)\Sigma$$

Finally, combining the agricultural production function, Eq. (7) and the Euler equation yield

$$y_a = z_a\left((1-\rho)\Sigma\frac{k_m}{n_m}\right)^{\mu} n_a^{\phi+\mu} = z_a z_m^{\mu/(1-\alpha)}\left((1-\rho)\Sigma\left(\left(\frac{1/\beta}{1-\tau}+\delta-1\right)\Big/\alpha\right)^{1/(\alpha-1)}\right)^{\mu} n_a^{\phi+\mu}$$

Appendix C. Employment by sector

The Chinese Statistical Yearbook (CSY) provides estimates of total employment and a breakdown of employment by industry: primary, secondary, and tertiary. There is a major adjustment in the CSY beginning in 1990, owing to employment increases observed in the Chinese Censuses of 1990 and 2000. These adjustments did not extend to years before 1990, leading to a big jump in the employment of all three industries. We have obtained data underlying Holtz (2006) that use information from the 1982 Census to adjust the pre-1990 data in a way analogous to the adjustment made for 1990 and after for all three industries.[10]

The CSY has information on total employment in State-owned enterprises, Collective and Cooperative units, TVEs, Private and other firms, and the Self-employed. 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. We use the ratios of public to total nonagricultural employment and private to total nonagricultural employment from the 2009 CSY, to allocate the adjusted employment data from Holtz (2006) to the private and public nonagricultural sectors.

Appendix D. GDP by sector

Real GDP in the agricultural and nonagricultural private and public sectors are reported in the CSY. We mainly use the CSY of 2009, which incorporates the 2006 revisions that increased the size of the tertiary sector. 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.[11] We then simply allocate total nonagricultural GDP to the public and private sectors; according to the allocation of gross outputs.

Appendix E. 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 1978–1995, Hsueh and Li (1999) report the sectoral distribution of GFCF in 26 provinces (all provinces other than Jiangxi, Guangdong, Hainan, and Tibet), accounting for an average of 78% 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 provinces. 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 data on fixed investment by ownership (State, TVEs, Collective, private, etc.) in the nonagricultural sector. This additional data are compiled from enterprise surveys; and its magnitude is about 10% 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 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. We use the investment in fixed assets price index as provided in the CSY to obtain our real investment figures.

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 et al., 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% between 1978 and 2003.

Appendix F. 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

[10] We thank Carsten Holtz for providing this data.

[11] 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.

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, 1978–2003, 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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